

HUBBLE SHOOTS THE MOON

# Astronomy

HDS 08070

July 1999 • \$4.50

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## *The* Pluto Dilemma

*Our Ninth  
Planet Begs for  
Definition*

The Real Men in Black

Seeking Alien Rocks  
in Antarctica

An American  
Astronomer in London





Now two ETX apertures!

ETX-90EC — \$595

ETX-125EC — \$895

Now you can buy the revolutionary Meade ETX® — the largest selling modern telescope in the world — in either of two apertures, 3.5" or 5". Both models include the very latest in microprocessor-controlled capability.

**New Fork Mount Designs with Standard-Equipment Dual-Axis Drive Systems:** Each with high-torque DC motors on both telescope axes, permitting electronic operation from the standard-equipment plug-in hand controller.

**Pushbutton Electronic Hand Controller:** Use at any of four dual-axis speeds: 8x for image centering at high power; 32x for image centering at lower power or for pushbutton object-tracking in the altazimuth mode; 0.75°/sec for image centering in the viewfinder or for terrestrial tracking; 5°/sec for fast slewing across the sky.

**Cordless Operation:** The dual-axis drive system operates for more than 40 hours from eight (user-supplied) AA batteries which store neatly inside the drive base.

**Optional Autostar™ Capability:** Plug in the optional Meade Autostar computer controller (see facing page) for LX200-type operation, including automatic GO TO capability to more than 14,000 celestial objects.

*Plus the features that created the ETX revolution:*

**Maksutov-Cassegrain Optical Systems:** Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that ETX telescopes often outperform other telescopes of larger apertures.

**Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter.

**SPECIFICATIONS: ETX-90EC and ETX-125EC Astro Telescopes** — Each includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8 or D = 127mm, F = 1900mm, f/15) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles and locks on both axes; electronic control panel; 4-speed (8x, 32x, 0.75°/sec, 5°/sec) dual-axis motor drive system with hand controller; sidereal-rate tracking in equatorial mode with optional table tripod or deluxe field tripod; internal battery compartment accepting eight (user-supplied) AA-size batteries; 8 x 21mm erect-image (ETX-90EC) or 8 x 25mm right-angle (ETX-125EC) viewfinder; Series 4000 Super Plossl 26mm eyepiece (1.25"); instructions. **ETX-90EC — \$595** (+ \$20 packing & shipping in the 48 states); **ETX-125EC — \$895** (+ \$30 P & S).

# MEADE

## ETX-90EC • ETX-125EC

**NEW!**

Meade ETX-90EC: \$595  
and ETX-125EC: \$895.  
Each complete as  
shown, with electronic  
hand controller; plus  
packing and shipping.



### OPTIONAL SYSTEMS\*

|                                             |        |
|---------------------------------------------|--------|
| #497 Autostar Computer Controller (90, 125) | \$149  |
| #880 Equatorial Table Tripod (90)           | 29.95  |
| #881 Equatorial Table Tripod (125)          | 59.95  |
| #883 Deluxe Field Tripod (90, 125)          | 199.95 |
| #825 8 x 25mm Right-Angle Viewfinder (90)   | 49.95  |
| #774 Hard Carry Case (90)                   | 99.95  |
| #775 Hard Carry Case (125)                  | 149.95 |
| #932 45° Erecting Prism (90, 125)           | 49.95  |
| #64 Photo Adapter (90, 125)                 | 34.95  |
| Electric Focuser #1244 (90) or #1247 (125)  | 119.95 |

\*see the Meade accessory ad in this issue.

### AUTHORIZED MAIL-ORDER DEALERS

- ASTRONOMICS**, Norman, OK.  
Orders: 800-422-7876; Info.: 405-364-0858.
- FOCUS CAMERA**, Brooklyn, NY.  
Orders: 800-221-0828; Info.: 718-436-6262.
- LUMICON**, Livermore, CA.  
Orders: 800-767-9576; Info.: 925-447-9570.
- OCEANSIDE PHOTO & TELESCOPE**, Oceanside, CA.  
Orders & Information: 800-483-6287.
- POCONO MOUNTAIN OPTICS**, Moscow, PA.  
Orders: 800-569-4323; Info.: 717-842-1500.
- RIVERS CAMERA**, Dover, NH.  
Orders: 800-245-7963; Info.: 603-742-4888.
- SHUTAN CAMERA & VIDEO**, Chicago, IL.  
Orders & Info.: 800-621-2248; IL: 312-332-2000.
- EFSTONSCIENCE**, Toronto, Ontario, Canada  
Orders & Information: 416-787-4581.
- KHAN SCOPE CENTRE**, Toronto, Ontario, Canada  
Orders & Information: 416-783-4140.



# Add the Meade Autostar™ computer to your ETX-90EC or ETX-125EC for automatic GO TO object location ...only \$149!



The Meade #497 Autostar Computer Controller (shown actual size) plugs in to the control panel of the Meade ETX-90EC or ETX-125EC telescope and permits LX200-type automatic object location from a 14,000-object database, a database that includes virtually every astronomical object visible with the ETX-90EC or ETX-125EC — \$149.

**Plug the #497 Autostar Computer Controller into your ETX-90EC or ETX-125EC and you're ready for an incredible array of LX200-type capabilities:**

**Automatic dual-axis GO TO function at 5°/sec** to any of more than 14,000 database objects, including deep-space objects (galaxies, diffuse nebulae, planetary nebulae, star clusters — the best objects from the IC, NGC and Caldwell catalogs, as well as all 110 Messier objects); 900 stars (double stars, variable stars, SAO stars); the 8 major planets from Mercury to Pluto; 26 of the brightest asteroids; 15 periodic comets; 50 earth-orbiting satellites; plus user-defined objects and the centroids of all 88 constellations. Select any of these objects, press **GO TO** and the telescope automatically slews to the object, placing it in the telescopic field.

**Automatic GO TO function to any object** of known R.A. and Dec.

**Digital readouts** of telescope position (continuously in R.A. and Dec.), menu options, glossary, and utility functions.

**Precise sidereal-rate tracking** in either altazimuth or equatorial modes. For altazimuth tracking, set the telescope on its drive base and perform a quick, easy alignment.

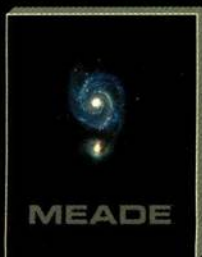
**9-Speed Dual-Axis Operation:** Pushbutton operation of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 5°/sec.

**RS-232 Serial Port:** For operation of the telescope through a personal computer, using Meade Epoch 2000® sky software or other sky software using the LX200 protocol.

**Plus:** over 20 other menu options, including guided tours, major event menus, user-defined terrestrial objects, and much more.



(right) Meade ETX-90EC, shown with optional #497 Autostar Computer Controller plugged into the telescope's control panel.



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# Astronomy®

COVER ILLUSTRATION: Lynette Cook



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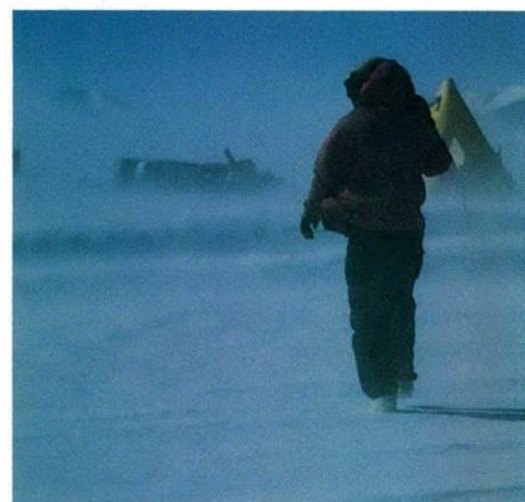
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# On Launching An E-zine



*astronomy* magazine welcomes you to the launch of its first online magazine, or e-zine: *Deep Sky Online*. Just come to our website at [www.astronomy.com](http://www.astronomy.com), and we'll show you the way to *Deep Sky*, where reports of fabulous observations will elaborate on the rare and treasured photos of those alluring objects that reside beyond our planets. *Deep Sky Online* will attempt to record and support the enormous change that has occurred in amateur astronomy in the past two decades. Huge Dobsonians are commonplace at star parties these days, and thousands of objects belonging to obscure catalogs such as Sharpless, Palomar, and Terzan have become regular telescope targets.

*Deep Sky Online* takes its name from the print publication *Deep Sky*, a baby sister to *Astronomy* magazine. *Deep Sky* was the creation of Dave Eicher, our managing editor, who first



produced it with 125 copies run on his father's mimeograph machine. Once acquired by Kalmbach Publishing, the magazine reached a total circulation of 14,000, testifying to the growth among serious amateurs and in

the size of telescopes — not to mention constantly improving editorial acumen. We will draw on the treasures left behind when *Deep Sky* stopped publishing in 1992, but we invite participation from all interested readers. Look for the site to start humbly and expand considerably. If you have thoughts, observations, stories or images to share, please send them to [deepsky@astronomy.com](mailto:deepsky@astronomy.com).

In the months ahead we will ask for new examples of craftsmanship and invention that the tinkerers among you would like to share with your peers. From telescope accessories to observatories, we want to know what you are building. Save the plans and send them along to us. A telescope-making e-zine is also on its way. (My personal favorite subject would be a round up of portable observatories.)

How can we ask for more from our faithful readers? Here's how: Hot Shots editor Kelly Whitt wants more short, witty, and/or amusing observing stories for the back of the book. Send yours to [hotshots@astronomy.com](mailto:hotshots@astronomy.com).

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# 8" LX10

# 8" LX10

## DELUXE

The optical performance of a Meade 8" LX200 Schmidt-Cassegrain...for only **\$995!**

**8" LX10:** For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard equipment includes:*

**Super-Multi-Coated Optical System:** The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. **Series 4000 SP26mm eyepiece:** Complements the exquisite imaging of Meade 8" SC optics. **Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. **Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours. **Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging. **Hand Controller:** Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

**SPECIFICATIONS: 8" Model LX10** — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **\$995.** (+ \$65 packing & shipping in the 48 states)

**8" LX10 Deluxe:** At only \$1149 the 8" LX10 Deluxe includes (a) the large-aperture Meade #544 8 x 50mm viewfinder (in place of the standard 6 x 30mm finder); (b) the LX10 Electric Declination Motor System, permitting dual-axis guiding corrections at 2x speed; and (c) Meade Epoch 2000 Jr. Sky Software with 10,000-object database — all at substantially lower cost than if the respective accessories were purchased separately.

**SPECIFICATIONS: 8" Model LX10 Deluxe** — Identical in all specifications to 8" Model LX10, above, but with Electric Declination Motor System provided as standard equipment, permitting dual-axis corrections at 2x speed; Meade #544 8 x 50mm achromatic viewfinder in place of 6 x 30mm viewfinder; and Meade Epoch 2000 Jr. Sky Software with 10,000-object database.

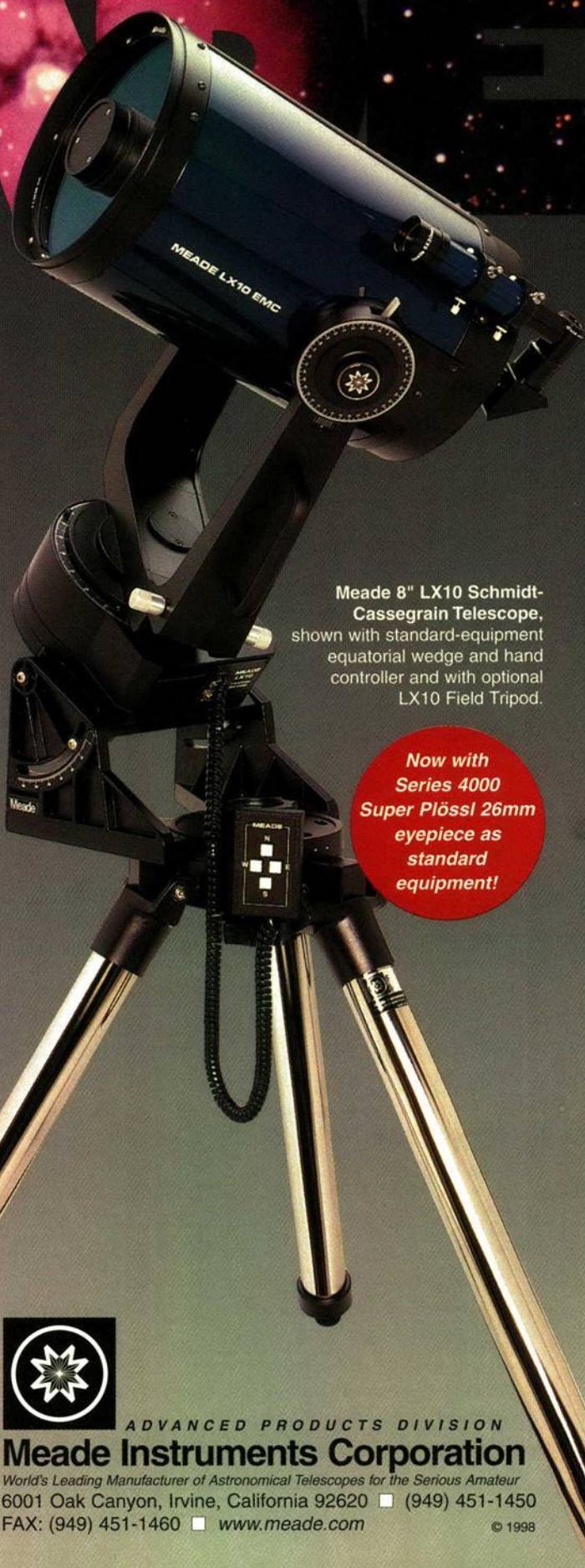
**\$1149.** (+ \$65 packing & shipping in the 48 states)

**Field Tripod for LX10 or LX10 Deluxe** . . . . . 195.

**Electric Declination Motor System for LX10.** . . . . 95.

**#2014 Magellan I Telescope Computer System for LX10 or LX10 Deluxe,**  
with 12,218-object database . . . . . 375.

The 100-page Meade General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers. Prices shown are suggested U.S. mail-order prices.



Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

Now with  
Series 4000  
Super Plössl 26mm  
eyepiece as  
standard  
equipment!



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## Advanced technology at the most affordable prices ever.

■ **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel.

■ **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for dual-axis drive capability at any of 4 photo-guide or microsllew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A.

■ **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector (*below*).

■ **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ **Massive LX200-type Fork Mounts:** Manufactured of the same aluminum castings as Meade LX200 models. Massive, rigid mounts that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications.

**SPECIFICATIONS:** 7", 8", and 10" LX50's — Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

|                              |         |
|------------------------------|---------|
| 8" LX50 Schmidt-Cassegrain   | \$1395. |
| 10" LX50 Schmidt-Cassegrain  | 1695.   |
| 7" LX50 Maksutov-Cassegrain  | 1795.   |
| Variable-Height Field Tripod | 295.    |

Packing and shipping in the 48 states: 8"—\$105; 10"—\$145; 7"—\$125; 7" Tube Assembly—\$65.

**Meade Magellan™ II Computer-Corrector for LX50 Telescopes:** Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■

Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.



**#2024: Magellan II for LX50's**—Includes Magellan II hand controller (*shown above*); encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **\$495.** + \$15 packing and shipping in the 48 states.

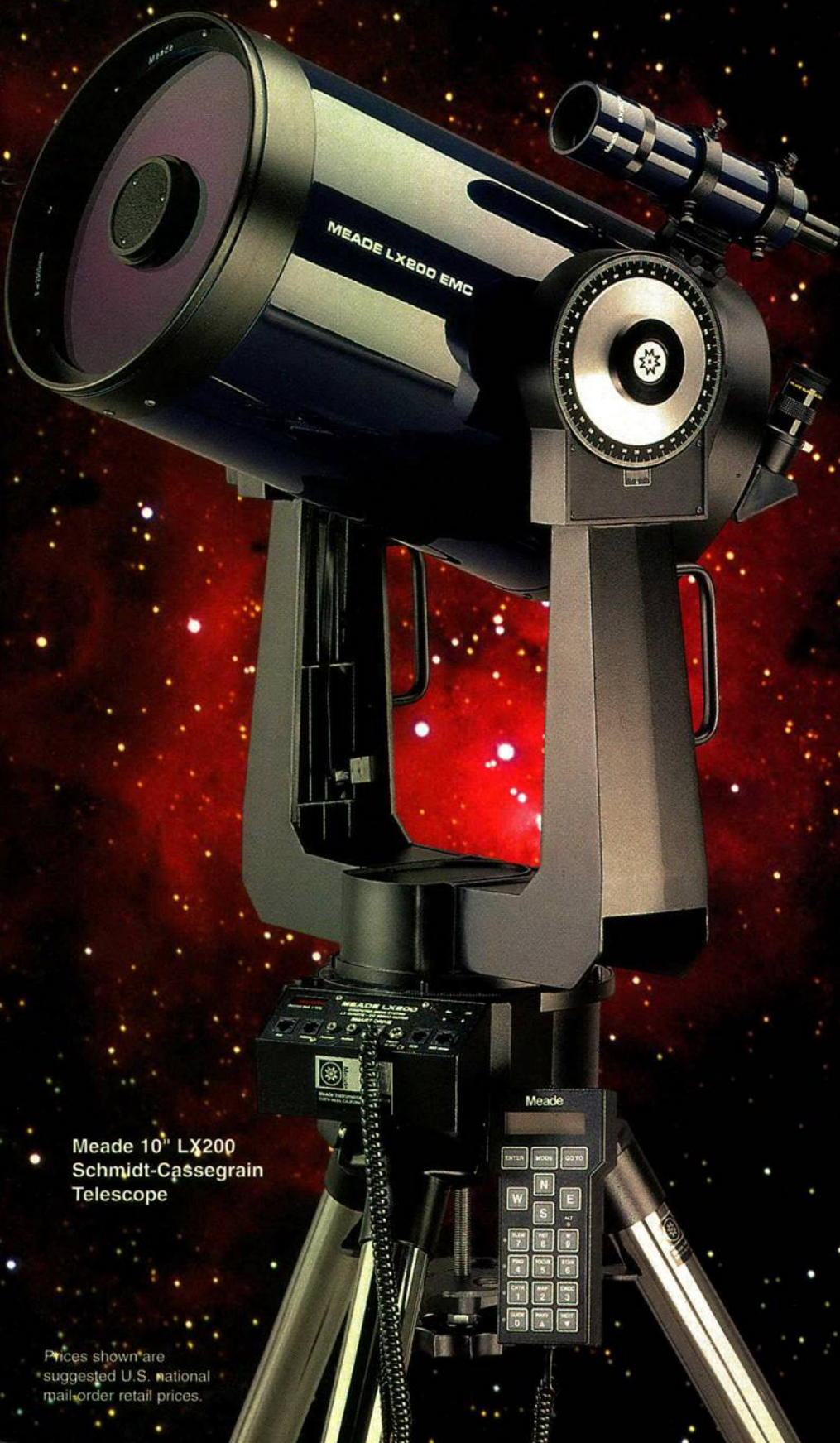
# Meade LX50



Meade 8" LX50 Schmidt-Cassegrain Telescope (*shown with optional Field Tripod*)



# MEADE LX200



Meade 10" LX200  
Schmidt-Cassegrain  
Telescope

Prices shown are  
suggested U.S. national  
mail-order retail prices.

## The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Standard-equipment includes:

■ **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; optical performance approaches that of a fine ED apochromatic lens.

■ **Automatic GO TO Capability:** Meade LX200's are the *only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, to a precision of *one arc-minute or better*.

■ **LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — a feat no other telescope priced under \$40,000 can accomplish.

■ **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.

■ **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.

■ **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The compact, optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug.

**SPECIFICATIONS:** 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

|                              |         |
|------------------------------|---------|
| 8" LX200 Schmidt-Cassegrain  | \$2795. |
| 10" LX200 Schmidt-Cassegrain | 3195.   |
| 12" LX200 Schmidt-Cassegrain | 4495.   |
| 7" LX200 Maksutov-Cassegrain | 3295.   |

Packing and shipping in the 48 states: 8"—\$105; 10"—\$145; 12"—\$215; 7"—\$125.

Write, call, or fax Meade Instruments for your free copy of the 100-page Meade General Catalog.



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# MEADE

## STARFINDER DOBSONIANS

Now with Series 4000 Super Plössl 26mm eyepiece as *standard equipment*! Consider these features:



**Series 4000 SP26mm Eyepiece (1.25"):** The premium SP26mm ocular permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities. This \$80 eyepiece is now **standard-equipment** on all Meade Dobsonians.

**Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass:** Unlike

the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

**Rigid, Durable, Beautiful Dobsonian Mountings,** manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

**Full-Size 1.25" Rack-and-Pinion Focuser:** For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

**4-Vane Steel Secondary Mirror System:** Permits locked-in support and precise centration and alignment of the secondary mirror.

**5 x 24mm Viewfinder:** Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

**Optical Tubes:** The same strong, spiral-wound Sonotubes™ used on Starfinder Equatorials (right),

tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

**Performance!** Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world. Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

**Packing & UPS Shipping Charges** to any address in the 48 states: 6"—\$39; 8"—\$49; 10"—\$69; 12.5"—\$79; 16"—\$45 packing, shipped truck freight collect.

### \$270 Dobsonian Deluxe Accessory Package...only \$49.95!



Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you

order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, **for a total of only \$49.95 additional:**

- 1 - Meade #77 2" Giant Rack-and-Pinion Focuser, with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. (reg. \$59.95)
- 1 - Meade #637 6 x 30mm Achromatic Viewfinder, with wide 7° field; 2-ring metal bracket. (reg. \$49.95)
- 2 - Meade Series 4000 Super Plössl 9.7mm and 26mm multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. (reg. \$79.95 each)

**Purchased separately, the Deluxe Accessory Package sells for \$269.80!**

### Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

- 7,840 NGC objects; the complete NGC catalog
  - 4,093 IC objects from the Index Catalog
  - 125 user-defined objects
  - 110 Messier objects; the complete catalog
  - 42 alignment stars for the Magellan system
  - 8 major planets, from Mercury to Pluto
- 12,218** objects, total

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.



**#2010: for Meade Starfinder Dobsonian**  
6", 8", 10", 12.5", or 16" ..... \$295.  
Packing & shipping in the 48 states—\$15.

### STARFINDER DOBSONIAN TELESCOPES Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.

All Starfinder Dobsonian and Equatorial models now with **Series 4000 Super Plössl 26mm** eyepiece as standard equipment!

6" f/8  
\$349

8" f/6  
\$449

10" f/4.5 \$599  
Shown with optional  
Magellan I Telescope  
Computer System

12.5" f/4.8  
\$895

16" f/4.5  
\$1195





# MEADE STARFINDER EQUATORIALS

With DC-powered drive systems for automatic tracking and Series 4000 Super Plössl 26mm eyepiece.

**Professional-Grade Optical System:** Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

**Accessories and Components:** Premium-grade multi-coated SP26mm eyepiece (1.25"); #637 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

**Precision Equatorial Mount:** Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

**Battery-Powered Cordless Drive System!** For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

**2" Giant Focuser:** Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

**Starfinder Equatorial 16:** Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

**Packing & UPS Shipping Charges** to any address in the 48 states: 6"—\$65; 8"—\$75; 10"—\$90; 16"—\$55 packing, shipped truck freight collect.

## Meade Magellan Telescope Computer Systems

**Magellan I:** Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan II for Starfinder Dobsonians (see facing page).



- #2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" ..... \$295.  
#2012: for Meade (DC-powered) Starfinder Equatorial 16" ..... 295.

**Magellan II Computer-Corrector:** Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, plus a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.



- #2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" .. 495.  
#2019: for (DC-powered) Starfinder Equatorial 16" ..... 595.

Packing & shipping in the 48 states: Magellan I—\$15, Magellan II—\$20.

**Special Eyepiece Offer!** At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece **for only \$29.95!** Purchased separately, the SP9.7mm eyepiece sells for \$79.95.



**New 120-page  
1999-2000 Meade  
General Catalog!**

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for your free copy.

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**FOCUS CAMERA, Brooklyn, NY.**  
Orders: 800-221-0828; Info.: 718-436-6262.

**LUMICON, Livermore, CA.**  
Orders: 800-767-9576; Info.: 925-447-9570.

**OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.**  
Orders & Information: 800-483-6287.

**POCONO MOUNTAIN OPTICS, Moscow, PA.**  
Orders: 800-569-4323; Info.: 717-842-1500.

**RIVERS CAMERA, Dover, NH.**  
Orders: 800-245-7963; Info.: 603-742-4888.

**SHUTAN CAMERA & VIDEO, Chicago, IL.**  
Orders & Info.: 800-621-2248; IL: 312-332-2000.

**Canada:**

**EFSTONSCIENCE, Toronto, Ontario.**  
Orders & Information: 416-787-4581.

**KHAN SCOPE CENTRE, Toronto, Ontario.**  
Orders & Information: 416-783-4140.



ADVANCED PRODUCTS DIVISION

**Meade Instruments Corporation**

The largest-selling telescopes in the world. ■ A NASDAQ company.

6001 Oak Canyon, Irvine, California 92620 ■ (949) 451-1450

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**STARFINDER EQUATORIAL TELESCOPES** Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.



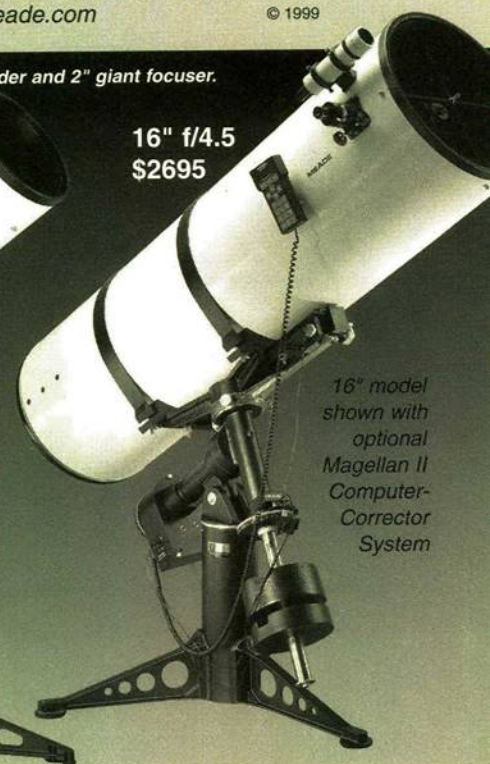
6" f/8  
\$649.95



8" f/6  
\$749.95



10" f/4.5  
\$879.95



16" f/4.5  
\$2695

8" model  
shown with  
optional Magellan I  
Telescope Com-  
puter System

16" model  
shown with  
optional  
Magellan II  
Computer-  
Corrector  
System



# RESEARCH-GRADE ACCESSORIES

## Series 4000™ Super Plössl

52° field; multi-coated



Meade 4-element Super Plössl, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers—a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

## Series 4000™ Ultra Wide Angle

84° field; multi-coated



The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

**Ultra Wide Angle (UWA); 8-elements; 1.25"; 84°—4.7mm: \$169.95 (5.26); 6.7mm: 199.95 (5.26); 8.8mm (1.25"/2"): 239.95 (7.02); 14mm (1.25"/2"): 299.95 (7.02)**

## Series 4000™ f/6.3 Focal Reducer/Field Flattenor

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **\$129.95 (5.26)**

## 2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **\$47.95 (4.54)**

## 2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **\$47.95 (4.54)**

## 2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25". **\$59.95 (4.54)**

## 2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. #930: Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders. **#929 or #930, each: \$99.95 (6.85)**

## 45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify #927 (.965"), #928 (1.25"), or #931 (fits .965" focuser, accepts 1.25" eyepieces). **\$42.95 (3.86)**

## Super Plössl (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm each: **\$79.95 (4.54)**  
32mm (52°): 40mm (44°) each: **99.95 (5.26)**  
56mm (52°; 2°) **199.95 (7.02)**

## World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. Internal batteries included. Bullseye reticle. 1.25". **\$149.95 (6.14)**

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **\$129.95 (5.26)**



Series 4000 Photo-Visual Color Filters (1.25")—Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #60A Blue; #62A Lt. Blue

each **\$14.95 (2.73)**

Set #1—4 filters: #12, #23A, #58, #60A **49.95 (4.54)**

Set #2—4 filters: #11, #25A, #47, #62A **49.95 (4.54)**

Set #3—4 filters: #8, #21, #38A, #56 **49.95 (4.54)**

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **\$16.95 (2.73)**

## #905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **\$49.95 (5.26)**

## Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **\$149.95 (7.48)**

#1205 Electric Focuser: For all other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery. **\$169.95 (7.88)**

## #777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-mount for your 35mm camera. **\$79.95 (6.85)**

## Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope—refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **\$79.95 (5.26)**

## Series 4000™ Super Wide Angle

67° field; multi-coated



For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)—13.8mm: **\$139.95 (4.54)**  
18mm: **149.95 (4.54)**; 24.5mm: **179.95 (5.26)**; 32mm (2°): **239.95 (7.02)**  
40mm (2°): **299.95 (7.02)**

## Series 3000™ Plössl

50° field; multi-coated



Meade Series 3000 Plössl yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössl, Meade Series 3000's are multi-coated for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm (far right in photo), an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössl yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössl (4-elements; 1.25"; 50°) 5, 6.7, 9.5, 16, 25mm each: **\$49.95 (3.86)**; 40mm (44° field): **\$79.95 (3.86)**



Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. 4-element "B" filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B—Threads into 1.25" eyepieces, 26mm dia. **79.95 (4.54)**

#910B—Threads into 2" eyepieces, 44mm dia. **119.95 (5.26)**

#911B—Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95 (5.26)**

#908N—Threads into 1.25" eyepieces, 26mm dia. **89.95 (4.54)**

#910N—Threads into 2" eyepieces, 44mm dia. **129.95 (5.26)**

#911N—Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **119.95 (5.26)**

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade 60-layer interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X—Threads into 1.25" eyepieces, 26mm dia. **99.95 (4.54)**

#910X—Threads into 2" eyepieces, 44mm dia. **159.95 (5.26)**

#911X—Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **149.95 (5.26)**

## Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated, threaded for filters; 1.25" barrel diameter. Apparent field: 40°. MA 9, 12, 25, 40mm. **each: \$37.95 (4.54)**

MA12mm Illuminated Reticle Eyepiece Excellent 3-element optical system, long eye relief, fully coated, with double crosshairs reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". Batteries included. **\$99.95 (3.45)**

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **\$79.95 (5.26)**

## Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately. **.965": \$27.95. 1.25": \$29.95 (3.86)**

## Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera. **\$39.95 (3.86)**

## T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-mount for your 35mm camera. **\$26.95 (3.86)**



## CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with any brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helioid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-thread or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured, they virtually eliminate all flexure between the CCD and telescope." — Jack Newton

**NEW!**

**#644 Flip-Mirror System:** Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **\$149.95** (7.02)

**#647 Flip-Mirror System:** Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

**#157 1.25" Adapter:** Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)



## Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only \$149!

**Epoch 2000sk** (upper display at left): Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields smaller than one arc second! With star positions displayed as precisely as 0.01 arc second, the Trapezium in Orion is no longer shown as a single point, as in other software, but as four precisely oriented starpoints, just as they appear in the telescope. No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field and updates R.A. and Dec. Instantaneously as the cursor is moved about the field. Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field to a precision of 30 arc seconds, routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

**Epoch 2000ip Image Processing Software** (lower display at left): Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

**EPOCH 2000sk Sky Software:** 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95. **\$149**

**EPOCH 2000sk-CD Sky Software:** 19 million objects, including the complete Hubble Space Telescope Catalog; supplied on CD-ROM. **179**

**LX200 Interface Cable:** for Meade LX200 operation by Epoch 2000sk. **25**

**EPOCH 2000ip Image Processing Software:** Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95. **\$199**



## Series 4000™ f/3.3 CCD Focal Reducer/Field Flatteners

Revolutionary 3-element Meade design permits ultrafast CCD imaging with increased edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to f/3.3 and f/6.3 SCT's to f/2. Variable T-Adapter (included) allows range of f/ratios between f/3 and f/2 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **\$149.95** (5.26)

## Plössl 25mm Illuminated Reticle CCD Framing Ocular

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror (above). Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **\$129.95** (4.54)

## #825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helioid focusing. **\$49.95** (4.26)

## #64 T-Adapter for ETX®

Threads to the photo port of all ETX-90 and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **\$34.95** (3.86)

## MA12mm Illuminated Reticle Astrometric Eyepiece

A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **\$119.95** (4.26)

## Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **\$219.95** (6.38)

## Pictor™ 201XT CCD Autoguider

Use the Pictor 201XT to take even the longest exposures, knowing that the telescope will precisely track the object being photographed or imaged. Can be used on any telescope equipped with a dual-axis drive corrector. On Meade LX50 and LX200 Schmidt-Cassegrains and on other telescopes with an "Autoguider" connector the 201XT plugs into the telescope's control panel. On telescopes where the drive corrector is not integrated into the electronics of the telescope itself, the optional #520 Electronic Relay is required. The Pictor 201XT is completely self-contained; no separate control box or PC is required. Used with an off-axis guider or guide telescope, the 201XT automatically locks-on the brightest star in the field (a star that can be as faint as 12th-magnitude), sets its own integration time, and actuates all required dual-axis corrections for superbly guided astrophotographs or CCD images. Incorporates TC-255 CCD chip and operates from 12v DC auto cigarette lighter plug with 25 ft. power cord, included. **\$395.** (7.02)

**#520 Electronic Relay:** Use with Pictor 201XT on telescopes without autoguider connector or with retrofitted drive corrector. **95.** (5.28)

**#541 AC Adapter:** For 201XT operation from 115v AC; includes 25 ft. cord. **35.** (6.56)

## ETX® Deluxe Field Tripod

Custom-designed by Meade specifically for ETX-90 and ETX-125 Astro Telescopes. Tripod height adjusts from 34" to 54", for seated or standing observations. Micrometric controls in azimuth and elevation permit precise polar alignment of the ETX fork mount. Tripod head tilts and locks to 90° for terrestrial applications. Telescope attaches to tripod in seconds with 2 thumbscrews. All-aluminum construction. **\$199.95** (10.00)

## ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, plus optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes two steel latches with key. **#774 Case for ETX-90 models: 99.95** (8.58) **#775 for ETX-125EC: 149.95** (13.38)

## ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories. **\$36.95** (5.26)

## Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with any ETX model. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus ETX/EC models through the telescope's hand controller. **#1244 Electric Focuser for all ETX-90 models: \$119.95** (6.85) **#1247 Electric Focuser for ETX-125 models: \$119.95** (6.85)

## #932 45° Erecting Prism for ETX®

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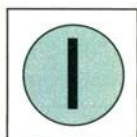
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# Going to Alpha Centauri? Not Likely.



In a recent issue of *Astronomy*, Rick Burges claims that the formidable difficulties of interstellar travel will be overcome — by progress. In his 1964 book *Beyond the Solar System*, Willy Ley uses the same kind of argument. Claiming that the first manned space-ships bound for Alpha Centauri will leave Earth about 2014, Ley admits he has no idea how such a journey will be made possible — but he asserts that inevitable progress will find a way.

Certainly there has been amazing progress since 1964 in such fields as computer science, genetics, and cloning — and in astronomy too. We have amassed a tremendous amount of knowledge about the universe, but we aren't an inch nearer Alpha Centauri.

In some early science fiction stories, space farers fought heroically to get to the moon, and as soon as they arrived, the rest of space magically opened for them. In the same way, Burges talks about going beyond our galaxy.

Human minds are incapable of grasping the vastness of the gulf that separates us even from Alpha Centauri. What we can understand are shows such as *Star Trek*, which encourage us to think that the tremendous costs and risks it will take to accelerate space-ships to a fraction of the speed of light are simply minor irritants. Perhaps it will be so, but it is far from certain. — Ann Sidbrant, Malm, Sweden

*At a typical shuttle speed of 17,600 miles an hour and a distance of 4.4 light-years (based on Hipparcos data), it would take 168,000 years (8,400 human generations) to get to Alpha Centauri. — Astronomy editors*

## Stars for a Wedding

In late 1992, Patricia Foster (née Bennett) of England placed an ad in the AstroMart section of *Astronomy* magazine, seeking correspondence with others. I replied and we main-

tained a steady correspondence after finding that we shared a number of common interests.

Eventually we met in person and finally decided to marry. The British government has just approved my visa application and our wedding will be in June 1999. I will be settling in her hometown of King's Lynn in Norfolk. And I'll be gaining a stepdaughter named Frances.

The purpose of this letter is to thank you for making this possible. I can't begin to say how much this has meant to us. As we enjoy stargazing together, we'll remember how our happiness started. — Steve Graham, Salem, Oregon

## Astronomy in Ghana

I am a Peace Corps Volunteer teaching physics and integrated science at Berekum Secondary School in Ghana. When I began teaching at this school, I discovered that the students lack the most basic knowledge of astronomy and aren't required to learn anything more than the names of the planets in our solar system. I decided that it's important for them to know more about the universe that they live in and began searching for ways to get them interested in it.

I was thrilled when a family member sent me the November issue of *Astronomy*. I was able to use the article "Leo's Incandescent Rain" to teach my class about meteorites, and then organized a group to go sky-watching the night of the Leonid meteor shower. The outing was a great success. It really piqued the interest of my students, most of whom had never taken the opportunity to look into the sky and wonder what is really out there. Afterward, my class was begging to learn more about planets, stars, comets, asteroids, and meteors. Unfortunately, my school has only an old set of encyclopedias and my *Astronomy*.

I would like to appeal to your readers for advice on teaching introductory

astronomy topics on a minuscule budget. I'd like to know about possible sources of donated or reduced-cost textbooks, materials, and equipment that could be used by my new Astronomy Club. — Erika Cooley, Peace Corps Volunteer, c/o Berekum Secondary School, P.O. Box 150, Berekum, Brong Ahafo Region, Ghana, West Africa.

## Keep Those Portraits Coming

I really enjoyed the Celestial Portraits features that ran in many issues of the magazine, and I am extremely disappointed to find the feature missing from my current issue. I wish you would continue to publish articles for observing the other constellations in their respective months. — Charles Rullmann, Islip Terrace, New York

*Never fear. It's our plan to continue publishing Celestial Portraits as long as Tom Polakis writes them. Unfortunately, we aren't able to squeeze one into every issue. — Astronomy editors*

## X-Files Science

How ironic that the editor visited an X-Files shoot while attending the annual meeting of the American Association for the Advancement of Science. *The X-Files* is probably the single biggest television influence hindering and distorting people's view of science and advancing crackpot theories and nonscience of all sorts. Appearing as a prop on *The X-Files* may be good advertising for *Astronomy* magazine, but it is pitiful that *Astronomy's* total influence is exclusively as a prop or source of props. — Kim Boriskin, Bellingham, Massachusetts

*We feel certain The X-Files producers will come under our good influence while reading Astronomy. — Astronomy editors*

## Boring Science is Dead

I would like to extend my thoughts concerning comments in the March



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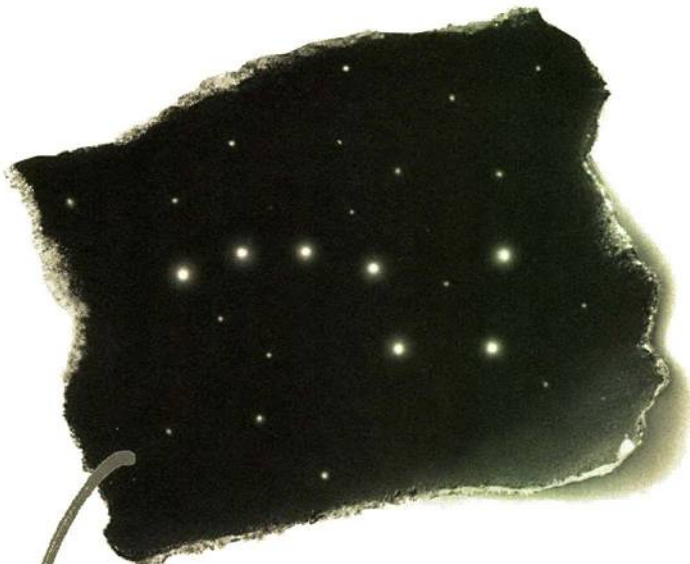
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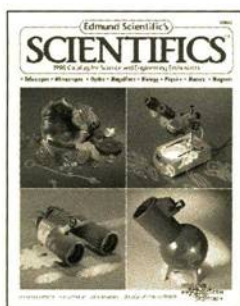
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## A TALKING BACK

and April issues about entertainment and science.

The days of boring science for scientists only are long gone. I teach high school science, including space science, in large part due to the excitement and entertainment of the Space Race. Science today is much more than an endless drone of facts and figures. That is what computers are for. I am determined not to make the same mistake that some of my own teachers made — conducting the boring science classes I had in high school. My students burn sulfur to compare the color change to those on Jupiter's sulfur-laden moon, Io. We build and fly rockets and even watch movies such as *Contact* and *Armageddon*. I believe my students end up with more interest in science. — *Dean Haley, Kyle, South Dakota*

### Paying Tribute

On March 27 1999, the astronomy community of Hamilton-Wentworth, Ontario, gathered at McMaster University's W. J. McCallion Planetarium to pay tribute to Grant W. P. Dixon. For more than 20 years, Grant has been a volunteer astronomy educator and planetarium host. He has introduced thousands of children and adults to the night sky at the W. J. McCallion Planetarium as well as at the Royal Astronomical Society of Canada Hamilton Centre's Leslie V. Powis Observatory in Flamborough.

Grant's contributions to astronomy education and the local astronomy scene were recognized with presentations from McMaster University's Physics and Astronomy Department, the Hamilton Amateur Astronomers, and the Royal Astronomical Society of Canada, Hamilton Centre. Every non-profit organization needs its share of dedicated volunteers. We are doubly fortunate to have such a passionate and selfless spokesman for the night sky. — *Ann Tekatch, Hamilton, Ontario, Canada* **A**

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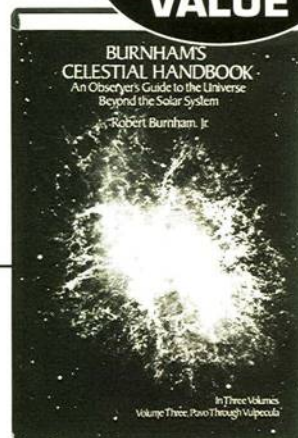
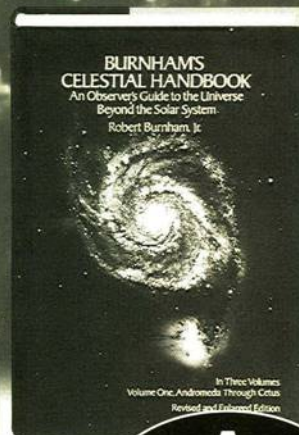
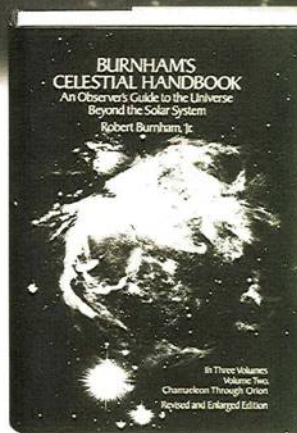
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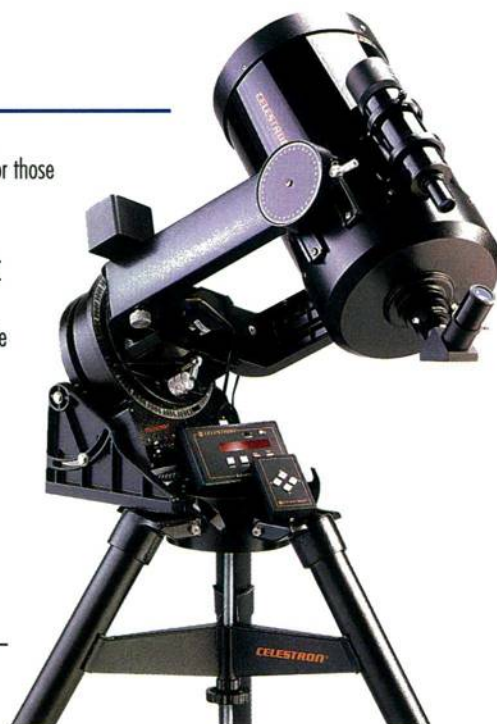
# CELESTAR 8 TELESCOPES

## CELESTAR 8

- Perfect for a first time astronomer.
- An economical but full featured 8" (2032mm f/10) Schmidt-Cassegrain. A considerable amount of engineering work went into the design of the Celestar 8.
  - No sacrifice was made in the optics. Celestron's carefully hand-figured system delivers diffraction-limited optics of unsurpassed quality. Starbright® coatings are standard.
  - The energy efficient DC electronics are powered by a 9 volt alkaline battery for easy astronomy on the go.
  - The totally cordless electronics have a built-in drive corrector which is activated when using the optional hand control. The R.A. motor's main tracking speed is an accurately regulated sidereal rate. The optional hand control allows for fast and slow override of R.A. tracking speed and  $\pm$  operation of the optional DEC motor. A comment from the Sky & Telescope review — "the digital electronics delivered a near-perfect sidereal tracking rate."
  - The Celestar 8 drive can operate in the Northern or Southern hemisphere from 0° to 90°.
  - The unique Wedgpod is a combination tripod and wedge which is very stable.
  - Made in the U.S.A.
  - Standard accessories include: 6x30 Finderscope, Star Diagonal — 1¼" and a 25mm SMA Eyepiece — 1¼" (81x).
  - Weight — 41 pounds.

## CELESTAR 8 DELUXE

- For the more serious astronomer.
- This telescope utilizes the same superior optics and has all the features of the Celestar 8, but is enhanced, for those who prefer a premium version.
- This model has a heavier duty fork mount and drive base, with a precision worm gear drive system.
- Superior tracking accuracy is attained with this advanced drive system, which has four tracking rates and PEC (Periodic Error Correction).
- For the kind of versatility that makes observing a pleasure, the hand controller makes available a micro guide rate of .5x sidereal and a slew rate of 8x sidereal.
- The stepper motor drive electronics are cordless and operate on two 9 volt batteries.
- The Celestar 8 Deluxe has many features that are necessary for the more serious amateur astronomer, particularly if you're interested in astrophotography or CCD imaging with the PixCel or other CCD cameras.
- Fastar compatible for f/1.95 CCD imaging — deep sky images in 30 seconds or less!
- Made in the U.S.A.
- The standard accessories for this telescope include: Declination Motor, Car Battery Adapter, Hand Controller, Wedge and a Tripod with adjustable height that's exceptionally rigid and sturdy.
- Also standard is a large 9x50 Finderscope, Star Diagonal — 1¼" and a multi-coated 26mm Plossl Eyepiece — 1¼" (78X).
- Weight — 52 pounds.



## ADVANCED ASTRO MASTER®



The Celestar 8 Computerized and the Celestar 8 Deluxe Computerized telescopes are the same as the Celestar 8 and Celestar 8 Deluxe but with the addition of a factory installed and tested Advanced Astro Master.®

Its pointing system contains a data base of over 10,000 objects. Once aligned, it will guide you to any one of these objects. Included are the entire RNGC catalog, the Messier catalog, IC catalog (selected objects), major planets, over 241 interesting double and multiple stars and a user definable catalog of 25 objects.

Operates on a standard 9V battery.

Contains an RS-232 serial interface to enable usage with programs like "The Sky"™ by Software Bisque.

For more detailed information on these telescopes, contact a Celestron dealer or Celestron. Visit our Web site at [www.celestron.com](http://www.celestron.com)



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# BRING THE UNIVERSE HOME WITH THE G-3 & G-5

Saturn's rings, galaxies light years away, bees buzzing in a patch of flowers – these images and many, many more can be yours with Celestron's new ultra-portable **G-3** and **G-5** telescopes. These large aperture, multipurpose instruments are full-featured systems ideal for terrestrial viewing, astronomical observing, telephotography as well as astrophotography and they come complete with equatorial mount, tripod, accessory tray and CD-ROM software.

They are the perfect sky-watching tools for amateur astronomers of all levels. Whether you're a first time user or a seasoned cosmic observer, you will appreciate the bright images, sharp contrast and exquisite detail provided by Celestron's legendary U.S.-made optics. Meticulously hand-crafted for optical excellence, the **G-3** and **G-5** are manufactured under strict quality standards.

## OPTICS:

- **G-3** – 3½" aperture, 1000mm f/11
- **G-5** – 5" aperture, 1250mm f/10

The **G-3** (Maksutov-Cassegrain optical design) and the **G-5** (Schmidt-Cassegrain optical design) deliver razor sharp images over a wide field. They both feature Celestron's world renowned hand-figured diffraction limited optical systems. Starbright® optical multicoatings provide maximum reflectivity and increased light transmission.



## MOUNT AND MOTOR DRIVE

An ultra-durable German equatorial mount is standard on the **G-3** and **G-5**. Setting circles and slow motion controls make it easier to locate and track objects manually. Setup is a breeze with the adjustable height aluminum tripod complete with deluxe accessory tray.

Automatic tracking of celestial objects is yours with the dual speed, single axis motor drive models as pictured above. A hand controller makes observing more fun as objects are easier to center. The built-in drive corrector, which runs on 4 "D" batteries, makes astrophotography possible. Non motor driven models are also available.

## STANDARD ACCESSORIES

A 25mm SMA eyepiece – 1¼" (40 power – **G-3**/50 power – **G-5**) is included. The **G-3** includes an 8x20 erect image finderscope and the **G-5** has a 6x30 finderscope.

A fun and educational CD-ROM, "The Sky Level 1 for Celestron," features a 10,000 object database and allows you to print your own custom sky charts.

Test out the new **G-3** and **G-5** at your Celestron dealer today and bring the Universe home.

For more detailed information on these telescopes, contact a Celestron dealer or Celestron. Visit our Web site at [www.celestron.com](http://www.celestron.com)



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# THE UNIVERSE IS JUST A CLICK AWAY WITH THE ULTIMA 2000

Combining state-of-the-art computer technology with a very stable fork mount and superb Celestron optics makes exploring our Universe fun, easy and exciting.

## OPTICS

8" Schmidt-Cassegrain Telescope, 2032mm Focal Length,  $f/10$ . Each optical system is individually hand figured and guaranteed to be diffraction limited. Multi-coated Starbright® coatings group for maximum light transmission and bright, high contrast images.

The optics are Fastar compatible which provides the potential for CCD imaging using the PixCel CCD camera at an incredible  $f/1.95$ ! Deep sky images in 30 seconds or less.

## MECHANICAL FEATURES

A quiet motor driven "go to" computerized telescope built entirely at the Celestron factory in Torrance, California. This "go to" scope won't disturb your neighbors.

Operates in the altazimuth configuration allowing you to find most objects in seconds. Simple to set up and use; all you have to do is find two alignment stars which are easily located on the laminated monthly star charts (included).

For long exposure astrophotography or CCD imaging, use the telescope in the equatorial configuration by adding an optional wedge.

The heavy duty fork mount is extremely rigid and sits on top of a sturdy, adjustable metal tripod. Yet, the telescope is extremely portable and convenient to take with you.

Two motors per axis are standard as well as precision worm gears in both axes that provide very smooth, accurate tracking ability.

The Ultima 2000 can be moved manually (by hand) without losing its star alignment.

## SOFTWARE/ELECTRONICS FEATURES

The power efficient DC telescope is operated with the included AA batteries. A built-in voltmeter monitors the status of the batteries. Optional adapters are available to run the telescope from a car battery or from an AC power source.

The standard, compact hand controller operates the various functions such as position, identify, speed, pointing, etc. 8 tracking and slewing speeds are available — sidereal, solar, lunar, King, 2x sidereal, 0.5x sidereal,  $2^\circ$  per second,  $10^\circ$  per second.

The Ultima 2000 has impressive pointing accuracy where the object selected will always be in the field of view of a low to medium power eyepiece. Includes Enhanced Encoder Resolution and Relative Go To mode for increased accuracy which is ideal for centering objects on a CCD chip.

The software database contains over 10,000 deep-sky objects as well as major planets. The objects include the entire Revised New General Catalog, the Messier catalog, selected objects within the IC catalog and the ESO and Uppsala catalogs, 241 interesting double and multiple stars, and 661 non-stellar objects. The database may not be the largest in the industry but it is one of the most useful because of the object selection. In addition, the display of the object data is the most complete of any commercial computerized telescope.

For beginners and educators, a special Tour mode is available which allows you to view 15 popular objects by season, automatically.

To quickly and easily find your favorite objects, the telescope offers 25 user-defined selections.

The Ultima 2000 can be operated by a computer using popular astronomy software such as *The Sky*. Programs can also be written by the user to control the telescope.

Other standard features and accessories include: 9x50 finderscope, multi-coated 26mm Plössl eyepiece —  $1\frac{1}{4}$ " (78x), star diagonal —  $1\frac{1}{4}$ " LED display, auto guider port, northern and southern hemisphere operation, comprehensive instruction manual.

For more detailed information on these telescopes, contact a Celestron dealer or Celestron.

Visit our Web site at [www.celestron.com](http://www.celestron.com)



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# CM TELESCOPES

Unequaled optical excellence combined with a superb new German equatorial mount. The mount and telescopes are manufactured by Celestron in Torrance, California.

Professional quality telescopes for serious astronomical work yet portable enough for field use.

## Optics:

- Legendary Celestron Schmidt-Cassegrains:
  - 11", 2800mm f/10 — CM-1100
  - 14", 3910mm f/11 — CM-1400
- Starbright® coatings

Lunar and planetary details are extraordinary when viewed through these instruments, and their large aperture and superb optics make for very exciting deep-sky observing of diffuse and planetary nebulae, open and globular star clusters, galaxies and binary stars.

Astrophotography and CCD imaging possibilities are endless. The 11" has been an astrophotography standard. Now the 11" and 14" coupled with the CI-700 mount raise the standards even higher. The 14" with the optional Fastar optics allows many **unguided** images at f/2!



## THE CI-700 MOUNT

also sold separately for medium and large aperture telescopes.

- Manual slow motion controls in both axes
- Preloaded bearings in both axes for smooth axis rotation and gear mesh
- 1" solid centerless ground shafts in both axes for higher payload capacity
- 180 tooth main gear (5.625" dia.) allows for longer unguided exposures
- 1/2" dia. precision 303 stainless steel worm gears for super accurate drive accuracy
- Large laser engraved setting circles — 5.25"
- Dual support fixed height tripod for maximum rigidity
- Machined aluminum and stainless steel
- 22# counterweight (44# with CM-1400)
- Built-in polar axis finderscope is standard
- All these technical features deliver the smoothness, precision, refinement and controllability that you've always wanted in a fine mount.

## DUAL-AXIS DC ELECTRONICS

- PEC (Periodic Error Correction)
- BC (Backlash Compensation) in declination
- Sidereal, solar, lunar, and King tracking rates
- .3x and .5x guiding rates
- 8x, 16x and 20x setting rates
- Hand controller operates simultaneously with all SBIG CCD imaging systems
- Car battery adapter
- Optional Advanced Astro Master® adapts easily with the specially designed hardware kit to computerize the telescope
- Standard accessories include: 9x50 finderscope, star diagonal and 26mm Plössl eyepiece.

For more detailed information on these telescopes, contact a Celestron dealer or Celestron. Visit our Web site at [www.celestron.com](http://www.celestron.com)



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# ACCESSORIES BY CELESTRON

The Celestron Accessories  
here are universal – use with  
virtually any telescope.

## PLÖSSL EYEPIECES

In a recent *Sky and Telescope* review, Celestron's 1/4" Plössl eyepieces were rated as **top ranking**, and found to outperform many similar, but more expensive eyepieces. An exceptional value! Celestron offers these premium eyepieces at affordable prices, yet they're among the best designed and corrected eyepieces available. They're **multicoated** for enhanced contrast and all models are threaded to accept Celestron colored eyepiece filters. **Focal length with field of view:** 6.3mm (52°), 7.5mm (52°), 10mm (52°), 12.5mm (52°), 17mm (52°), 20mm (52°), 26mm (50°), 32mm (52°), 40mm (46°).



## ULTIMA® EYEPIECES

These are Celestron's top of the line 1/4" eyepieces. They feature long eye relief and a wide field, and each air-to-glass surface is **fully multicoated** to enhance contrast levels. These special eyepieces are computer designed to keep visual aberrations to an absolute minimum. Recently, *Sky and Telescope* reviewed Celestron's Ultima® eyepieces and rated them **best in their class**, with greater contrast and image sharpness than the competitive models of other manufacturers. The inside surfaces and edges of all lenses are blackened, to keep out reflected light. Threaded barrels accept Celestron thread-in filters. **Focal length with field of view:** 5mm (50°), 7.5mm (51°), 12.5mm (51°), 18mm (51°), 24mm (51°), 30mm (50°), 35mm (49°), 42mm (36°).



## LV EYEPIECES

These Vixen brand 1/4" eyepieces (6 to 8 elements) are a new breed, using the rare earth glass lanthanum in one of their field lenses, for almost total freedom from any visual aberrations. All focal lengths have a comfortable 20mm of eye relief. Even when using the 2.5mm LV eyepiece on a telescope, you'll have eye relief of 20mm! These eyepieces also feature **fully multicoated** lenses for optical excellence. **Focal length with field of view:** 2.5mm (45°), 4mm (45°), 5mm (45°), 6mm (45°), 9mm (50°), 10mm (50°), 12mm (50°), 15mm (50°), 20mm (50°), 25mm (50°).



## LV ZOOM EYEPIECE

This super premium 1/4" zoom eyepiece has a focal length of 8mm to 24mm. It is the finest zoom eyepiece for low to medium power observing. It's an excellent eyepiece that performs superbly, with **fully multicoated** surfaces. It offers an apparent field of 40° at 24mm and 60° at 8mm. Eye relief ranges from 15mm to 19mm.



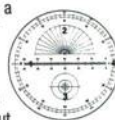
## CROSS HAIR EYEPIECE

This 1/4" eyepiece is the Kellner design, with a focal length of 20mm. It's ideal for centering alignment stars when using digital setting circles or computerized telescopes. A useful all-around eyepiece for many applications, including terrestrial observing.



## MICRO GUIDE EYEPIECE

This multifunction 1/4" guiding eyepiece features a laser-etched reticle with a built-in battery illuminator. The eyepiece is a **multicoated** 12.5mm Orthoscopic. Usage possibilities include: direct guiding on stars outside the center of the field of view; greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude; and measuring position angles and separation of double stars. **Its finely etched micrometer scale** has graduations 50 microns apart and 15 microns wide. Included are: the eyepiece, built-in cordless illuminator with adjustable brightness control, batteries and instructions.



## BARLOW LENSES

Celestron's premium quality .96" and 1/4" achromatic Barlow lenses are compact and lightweight. Both are under three inches long, with the 1/4" lens weighing in at 4 ounces and the .96" lens a mere 2 ounces! The clear aperture is 27mm on the 1/4" model, and 21mm on the .96" unit. The .96" Barlow is **fully multicoated** and the 1/4" lens is **multicoated**. The Ultima® Series Barlow (2x – 1/4") is an air-spaced, three element apochromatic design with a 27mm clear aperture. This lens features a very high quality, **fully multicoated** design. Amazingly compact and lightweight, it's just 5 ounces and 2 1/4" in length.



## DIAGONALS

Celestron's Erect Image Diagonals are an Amici prism design. This design allows you to look into the telescope at a 45° angle, at images that are oriented properly, meaning the image is upright and correct from left to right. .96" to 1/4" models are available. Use of Celestron's hybrid .96" to 1/4" 45° Erect Image Diagonal on a telescope equipped with .96" eyepieces means greater versatility. This diagonal will allow you to use 1/4" eyepieces to obtain a larger field of view and better eye relief. A 90° 1/4" Erect Image Diagonal is available for those who prefer that angle. A 1/4" Star Diagonal (90°) is also available.



## EYEPIECE FILTERS

Eyepiece filters are an invaluable aid in lunar and planetary observing. They reduce glare and light scattering, increase contrast through selective filtration, increase definition and resolution, reduce irradiation and lessen eye fatigue. Celestron's filters are made of high quality, solid plane parallel glass with excellent homogeneity. They're **antireflection coated** to prevent glaring and ghosting. All eyepiece filters are threaded to fit Celestron's, and most other manufacturer's, 1/4" eyepieces, and offer a full 26mm clear aperture. Filters available individually are: #12 Deep Yellow, #21 Orange, #25 Red, #58 Green, #80A Light Blue, #96 – 25% T, #96 – 13% T, Polarizing. In addition four different sets of four filters each are available.



## 1/4" POLARIZING FILTER SET

It's particularly useful for reducing glare while observing the moon, double stars, the planets and terrestrial subjects. You can vary the degree of transmission. By causing the amount of transmitted light to vary, the filters become, in effect, a continuously variable neutral density filter.



## LPR FILTERS

Light Pollution Reduction (LPR) Filters are designed to selectively reduce the transmission of certain wavelengths of light, specifically those produced by artificial light. As a result, Celestron LPR Filters darken the background sky, making deep-sky observation of nebulae, star clusters and galaxies possible from urban areas. While blocking unwanted light, Celestron LPR Filters permit the transmission of more desirable wavelengths. This will improve your viewing of emission nebulae, both from urban and rural settings. They're also protected with a **broadband antireflection coating** to prevent ghosting and to improve contrast. They provide superior performance and contrast over competitive models. A 1/4" model threads into 1/4" eyepieces to work with virtually all telescopes.



## MOON FILTERS

Celestron's Moon Filter threads into 1/4" eyepieces and aids in reducing the brightness of the moon and improving contrast, so greater detail can be observed on the lunar surface. The clear aperture is 21mm.



## VIBRATION SUPPRESSION PADS

Telescope vibration is caused by windy conditions, an unsteady mount or tripod or even an accidental bump to the instrument, and results in reduced image quality. Celestron's set of three Vibration Suppression Pads **will reduce vibration time by almost 100%** and decrease vibration amplitude. The pads fit between the bottom of the tripod legs and the ground, a simple and functional solution to the problem of image disturbance.



## NIGHT VISION FLASHLIGHT

Celestron's premium model for astronomy uses **two red LEDs** to preserve night vision better than red filters or other devices. Brightness is adjustable. Operates on a single 9 volt battery (included).



## LENSPEN™

A superb new tool in optical lens cleaning technology. Perfect for cleaning binocular lenses, small aperture spotting scopes and telescopes, eyepieces, and other optical items. The LensPen™ comes with a handy retractable dust removal brush and a special non-liquid cleaning element, designed to never dry out. Safe and very easy to use.



## SKY MAPS

Celestron Sky Maps are the ideal teaching guide for learning the night sky. You wouldn't set off on a road trip without a road map, and you don't need to try to navigate the night sky without a map either. Even if you already know your way around the major constellations, these maps can help you locate all kinds of fascinating objects. The front cover has a specially designed **luminous planisphere** that rotates to simulate the seasonal progression of celestial objects through the sky. When the planisphere is pre-exposed to light, star positions glow brightly against a dark background, mimicking actual constellations. More than a thousand stars and deep-sky objects are listed and charted.



## PLANISPHERE

A simple and inexpensive tool for all levels of observers, from naked eye viewers to users of highly sophisticated telescopes. The Celestron Planisphere makes it easy to locate stars for observing and is a great planet finder as well. The Celestron Planisphere comes in three different models, to match the latitude from which you're observing: 20° to 40°, 30° to 50°, 40° to 60°.



## TELESCOPE EQUATORIAL MOUNT-CG-3

A durable, rigid, German equatorial mount with a wooden tripod, offering both affordability and high quality. Designed as an excellent and inexpensive upgrade option when you're ready to move to a sturdier mount for your beginning telescope. R.A. and DEC setting circles, a latitude scale, slow motion controls and a handy accessory tray are included.



## TELESCOPE EQUATORIAL MOUNT-CG-4

The CG-4 mount is a very rigid German equatorial mount. A counterweight, latitude scale, setting circles and slow motion controls on both axes are standard. The adjustable height aluminum, rigid tripod has **excellent damping characteristics** and a handy accessory tray. It is the same mount as used on Celestron HD telescopes and is a step up from the CG-3. Optional motor drives and a polar alignment finderscope are available.



## TELESCOPE EQUATORIAL MOUNT-CG-5

The CG-5 EQ mount is the newest generation of Celestron's German mounts. Both axes of the equatorial mount have **precision worm gears** for extremely smooth motion. It is a step up from the CG-4. This **heavy-duty mount** delivers jitter-free images easily and the adjustable height aluminum, rigid tripod has excellent damping characteristics and a convenient accessory tray. Included are setting circles on both axes, slow-motion controls and latitude scale. An adjustable counterweight makes it easy to point, balance and use. An optional polar alignment scope for fast polar alignment as well as motor drives are available for easy tracking.



## ALT-AZ PHOTO TRIPOD MOUNT

This heavy-duty mount is perfect for cameras with large telephoto lenses, and for spotting scopes and binoculars. If you already own a small telescope mount and are interested in one offering greater stability, the Alt-Az is an ideal upgrade. The adjustable wood tripod comes with two slow motion cables and is equipped with a 1/4" x 20 photo head.



For more detailed information on these and other Celestron Accessories, contact a Celestron dealer or Celestron. Visit our Web site at [www.celestron.com](http://www.celestron.com)



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# AVOID STORAGE PROBLEMS

Before you buy a tripod for your ETX 90/EC—Ask the question, "Where do I store the Autostar hand unit?" The JMI Wedgepod has the best answer!!!

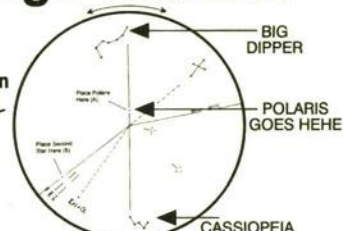
**NEW! Smart MOTOFOCUS for 90/EC!** JMI now has MOTOFOCUS compatible with the ETX 90/EC—Plugs directly into the aux jack—No hand control is provided, since it works with manufacturer's hand control.  
MOTOFOCUS for 90/EC \$99.95 (\$6)  
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**MOTODEC™** for most popular Telescopes as low as \$89.95 (\$6)

**BREAK THROUGH** Integrated Digital Focus Counter with Heavy Duty MOTOFOCUS—Great for CCD work 999 on display = 10 turns.

Fits all Meade and Celestron SCTs and MAK's, 7" through 14" MOTOFOCUS with DFC \$159.90 (\$8)  
Works with manufactures hand unit. Add \$10 if you require JMI's hand control.

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Move your scope with ease, level, lock the wheels, fits most Meade 2080/2120, Starfinder 6/8/10, most SCT's up to Ultima 11, adjustable tip-to-tip distance 31 to 36 inches.

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**Meade Giant Field Tripod.** Fits Meade 12 inch, tip-to-tip distance 51 inches.

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245 objects!

**NGC-miniMAX \$59.00 (\$8)**  
Planets, polar align help, 3900+ objects!

**NGC-Max \$699.00 (\$8)**  
Planets, polar align help, "Grand Tour" (identify), RS-232, 12,000+ objects!

**NOTICE! ETX NO LONGER CARRY-ON**

new airline limits are 22" X 14" X 9". Our cases and others measure 19" X 15 3/4" X 8". Some airlines are hard nosed, some are not...check with yours.

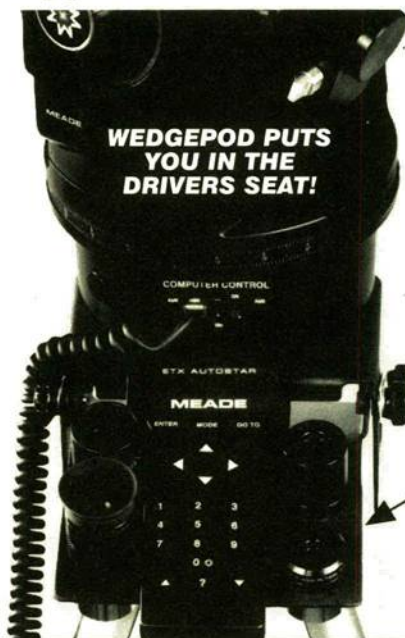
- Professional Die-Cut Foam Lining -Top & Bottom (No cubes to fall out).
- Compartments to hold 5 to 6 eyepieces, barlows, hand controls, etc.
- Keys included to Secure ETX & Accessories.

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Adjust to 24" to 55"  
**Wedgepod Case 99.95 (\$8)**

**90° FINDER CONVERSION KIT**

Converts Straight Through to 90°  
\$49.95 (\$5)

Before you buy a carrying case ask about the **FOAM**—if it's not 1.85 Density & IFD (Indent Force Deflection) 110 lbs, it's not a JMI Case!!!

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## SPACE WEATHER

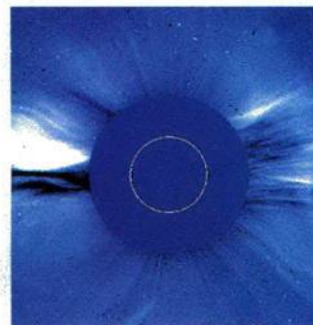
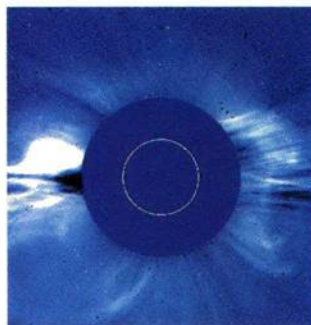
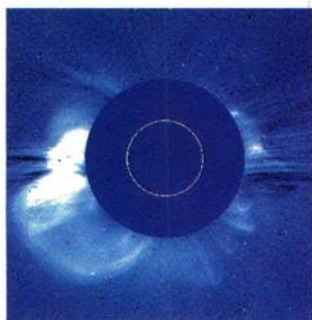
# Forecast: Space Storms Due in 2000-2001

► Weather forecasters on Earth monitor cloud patterns to gauge the chance of storms five days in the future. In a similar way, astronomers are learning how to spot patterns on the sun that portend rough "space weather" ahead.

Instead of cloud patterns, solar physicists look for coronal mass ejections (CMEs), billion-ton blobs of charged gas that billow into space from the sun's atmosphere. If a CME moving one million miles an hour hits Earth, it can wreak havoc as it smashes into our planet's magnetic field. Such fierce clashes can trigger surges of electrical current that short-circuit satellites and damage electrical-power networks on the ground.

Astronomers and electric utilities are bracing for an onslaught of CMEs because the peak of the sun's 11-year cycle of activity will be in 2000 and 2001. Solar satellites currently are revealing that magnetic storms around Earth are more predictable than once thought. For instance, researchers watch for "halo CMEs" with instruments on the Solar and Heliospheric Observatory (SOHO). Halo CMEs brighten the entire rim of the sun's corona, revealing that gas is headed directly toward us rather than off to the side. Magnetic storms often hit Earth about three days after SOHO sees the coronal brightening.

The most powerful CMEs spawn waves that spread in the corona like



This sequence of coronagraph images shows a "halo coronal mass ejection" in the process of lifting off the sun (obscured by a disk) and heading toward Earth in 1997. SOHO, LASCO, NRL, Max-Planck Institute, Laboratoire d'Astronomie,

University of Birmingham

ripples from a stone tossed in a lake. Further, CMEs with magnetic fields that oppose the direction of Earth's field pack the biggest punch. SOHO sees those alignments by measuring the direction of magnetic fields on the sun beneath the CMEs.

X-ray pictures from Yohkoh, a Japanese solar satellite, show that many active regions on the sun's surface contort into S shapes before erupting. These "sigmoids" reveal stressed magnetic fields, like rubber bands twisted around each other repeatedly until they snap, says solar physicist Richard Canfield of Montana State University. Further analysis should enable researchers to assess the probability that a sinuous active region will erupt within a few days.

"We see this as a harbinger of the future," says Ernest Hildner, director of the National Oceanic and Atmospheric Administration (NOAA) Space Environment Center in Boulder, Colorado. Starting

in 2001, a NOAA satellite will take x-ray images of the sun every minute. Computer programs will scour those images for sigmoids, to automatically alert forecasters in the same way that tight swirls in a thunderstorm often are a tip off to tornadoes. — ROBERT IRION

## HUBBLE SPACE TELESCOPE

### Spring Storms Strike Uranus

► For those who live in the central United States, springtime conjures up images of blooming flowers and growing grass. But there's a dark side to spring as well. As the sun climbs higher in the sky and dumps more energy into the atmosphere, the threat of severe thunderstorms — and even tornadoes — looms over this otherwise idyllic season.

While the temperatures may be colder than Earth's

and the flora nonexistent, springtime on the planet Uranus is shaping up as a time for even more-impressive storms. A new time-lapse movie created by Erich Karkoschka of the University of Arizona from images taken by the Hubble Space Telescope between 1994 and 1998 shows for the first time seasonal changes on the planet. Massive storms more than a thousand miles across with cloudtop temperatures dipping to  $-300^{\circ}$  Fahrenheit are seen erupting in the seventh planet's thick atmosphere as spring approaches in the northern hemisphere. You can view the movie on the world wide web at <http://opposite.stsci.edu/pubinfo/pr/1999/11/animations.html>.

Storms aren't the only stars of the new movie. Equally fascinating is the planet's ring system, which wobbles about like a wheel out of balance.

The wobble apparently arises from the flattened shape of Uranus acting in concert with the strong



gravitational pull from the planet's many moons.

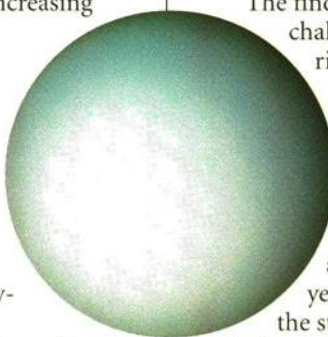
The stormy weather comes as a surprise to many astronomers, who remember Uranus as the blandest of planets when the Voyager 2 spacecraft flew by in January 1986. But the northern hemisphere was then in the grips of a bitterly cold decades-long winter.

Unlike any other planet in the solar system, Uranus circles the sun with its axis lying nearly in the plane of its orbit. That means each season lasts for about one quarter of its 84-year long orbit (see "Reasons for the Seasons," page 74). In 1986 the south pole of the planet was pointing almost directly at the sun and the northern hemisphere received no sunlight whatsoever. Now with spring approaching, sunlight is reaching parts of the atmosphere it hasn't hit in decades. The increasing illumination apparently drives the storms seen by Hubble.

Although hints of atmospheric activity were reported by several observers earlier this century, the Hubble observations offer the first modern proof that the planet experiences storms similar to those seen on the other gas giant planets. Now planetary researchers can only wait to see what atmospheric changes occur as the sun continues climbing higher into the uranian sky. —

RICHARD TALCOTT

**Bland and boring when viewed up close by Voyager 2 in 1986 (seen here), Uranus now shows signs of strong spring storms. NASA/JPL**



## EXTRASOLAR PLANETS

# Three Big Planets Orbit Nearby Star

► The recent discovery of one Jupiter-sized and two larger planets orbiting a nearby sunlike star suggests to astronomers that planetary systems similar to ours might be ubiquitous throughout the Milky Way Galaxy. "Within 5 or 10 years we will find smaller planets like those in our solar system," predicts Paul Butler, a San Francisco State University astronomer and one of the discoverers.

The finding poses a challenge to theorists: How can nature cram three massive planets so close to a star?

Located about 44 light-years from Earth, the star Upsilon Andromedae is slightly larger and hotter than our sun. The three planets were discovered indirectly through an analysis of the wobbles in Upsilon Andromedae's motion relative to Earth that are caused by the gravitational tugs of the three unseen planets. The three planets have minimum masses of 0.72, 1.98, and 4.11 Jupiters and they orbit the star at 0.05, 0.83, and about 2.5 astronomical units (AUs) respectively. (One AU is the distance between Earth

and the sun, or about 93 million miles.) Butler and Geoff Marcy, a colleague at San Francisco State University, discovered the inner planet back in 1996. Butler and Marcy, along with a team led by Robert Noyes of the Harvard-Smithsonian Center for Astrophysics (CfA), independently discovered the two outer planets.

The three planets are unlikely to harbor advanced life. The inner planet is so close to Upsilon Andromedae that it would be much too hot. The outer two planets would have extreme temperature fluctuations because their elliptical orbits would warm and cool them.

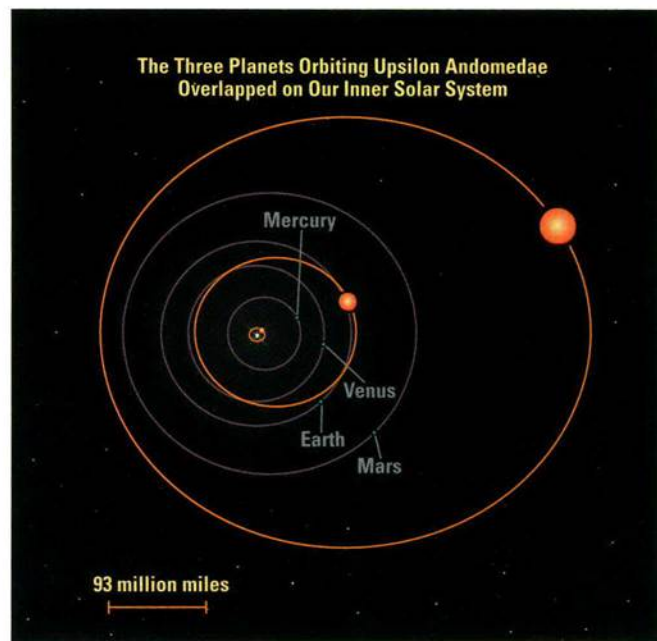
Intensely hot wind of a young star would drive away gas from the inner part of an infant planetary system. Therefore, most astronomers think the newly discovered planets formed much farther away from Upsilon Andromedae and migrated inward. Any Earth-like planet orbiting the star at a hospitable distance from the star would have been ejected

from the system by the inward movement of the larger planets.

About 18 other extrasolar planets, most orbiting close to their parent stars, have been discovered by Marcy, Butler, and others. Marcy noted that theories of planetary-system formation don't predict the kind of three-planet system discovered around Upsilon Andromedae.

"Finding three planets around a solar-type star draws a bridge across the gulf between our solar system and the other extrasolar planets we've been finding," Marcy said in a news conference April 15 at San Francisco State. "We are witnessing the emergence of a new era in human exploration. How does our solar system compare to other planetary systems? Is our own solar system unusual in some way? Is it a cosmic quirk of nature? Is our own Earth a common type of planet? Our discovery answers none of these questions; it asks them."

— ROBERT NAEYE



Astronomy: Kellie Jaeger



ELLIPTICAL GALAXIES

# Hot-dog Galaxies?

▶ Astronomers know little about the three-dimensional shapes of elliptical galaxies even though the name suggests they are football-shaped. For example, an elliptical that looks like a circular halo could be a sphere, a disk, or an ellipsoid shape.

However, after observing the motions of stars within elliptical galaxies, Ohio University astronomer Thomas S. Statler says the ellipticals his team has studied seem to prefer the shapes of hamburger buns or hot dogs. "The strength of this tendency should be an important clue to understand how elliptical galaxies form and evolve," says Statler. In the January issue of *The Astronomical Journal*, he reported that NGC 1700, an elliptical galaxy in Eridanus, fits in the hamburger-bun class.

"Very few elliptical galaxies have been observed deeply enough to get data of sufficient accuracy to play this game that we played with 1700," says Statler. He, graduate student Jakob Bak, and others have determined the three-dimensional shapes of nine elliptical galaxies using their observations and the observations of others. The process is slow because eight hours of observing time with a 4-meter ground-based telescope are required to determine the shape of one elliptical galaxy.

The star-motion data also is essential in reconstructing a galaxy's life history. "This is important,"



he says, "because the theories of elliptical-galaxy formation produce objects of different shapes in computer models."

David Merritt, an astronomer at Rutgers University and an expert on elliptical galaxies, says the work of Statler's group is important. "However, instead of hamburger buns and hot dogs," says Merritt, "I call them pancakes and sausages."

Merritt says he and other elliptical-galaxy researchers are intrigued by the role that supermassive black holes at the cores of elliptical galaxies seem to play in shaping them. "Any star that comes close to a black hole finds its trajectory strongly perturbed," he says. "This randomizes the orbits and produces chaos." The net effect is a very efficient conversion of galaxies with three axes of symmetry into galaxies with one axis of symmetry, shaped either like hamburger buns or hot dogs, but most often buns. "Even in spiral galaxies, the black holes tend to be buried in the central bulge, which is sort of a semi-elliptical galaxy at the

**This elliptical galaxy, NGC 1700, apparently is shaped like a hamburger bun.** STScI/Digital Sky Survey

center of the galaxy," he says. The stars in the arms of a spiral galaxy don't end up in the bulge because their circular orbits keep them too far from the black hole to be affected by it. — REX GRAHAM

GREENHOUSE RIDDLE

# Modeling Deepens Mystery of Earth's Heat

▶ The late Carl Sagan and his colleague Christopher Chyba proposed a solution to a mystery about the first billion years of Earth's history: Why was Earth warm enough to keep its oceans from freezing solid even though the sun was 30 percent fainter than it is today?

Sagan and Chyba had suggested that early Earth's

atmosphere must have allowed sunlight to penetrate it while also preventing the resulting heat from escaping into space. Early Earth had a major greenhouse gas — ammonia — but solar ultraviolet light would have destroyed it. Sagan and Chyba said Earth must have had a smoggy layer of haze that protected ammonia from ultraviolet-light destruction and warmed the planet.

Earth's current atmosphere has significant amounts of two other greenhouse gases — water vapor and carbon dioxide. Those gases keep Earth's surface 63° F (17° C) warmer than it would be without them. However, to keep early Earth from freezing, ammonia gas would have had to keep Earth at least 90° F (32° C) warmer that it would have been without it. Astronomers can't explain this huge greenhouse effect, which they call the "faint young sun paradox."

In the January 1999 *Icarus*, Christopher McKay of NASA's Ames Research Center, along with Ralph Lorenz and Jonathan Lunine of the University of Arizona, argue that the paradox is even more baffling than both Sagan and Chyba had realized.

McKay's group modeled the atmosphere of Saturn's large moon Titan, which has an atmosphere similar to the one thought to have existed on early Earth. Surprisingly, the group's model indicates that Titan's haze produces a cooling effect instead of a warming effect: The haze not only prevents most solar visible light from reaching the surface of Titan and warming it, but it



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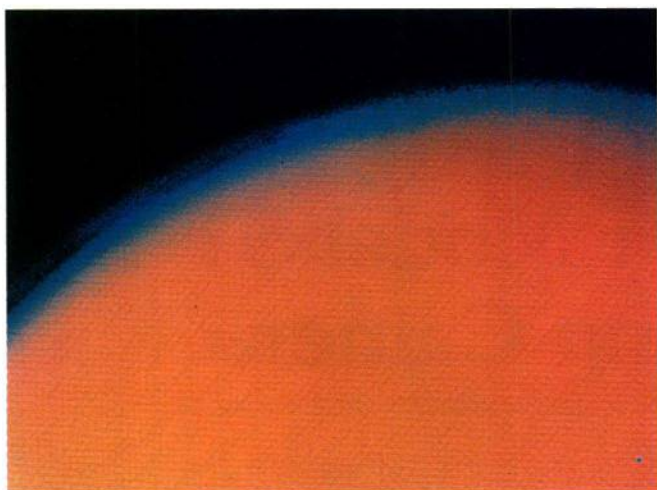
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also allows the heat that is produced on the planet to escape into space. This combined effect cools Titan's surface by 16° F (−9° C).

"This argues that the Sagan-Chyba suggestion may not get early Earth out of its predicament," says Lorenz. "We still have not resolved the faint young sun paradox." — ROBERT NAEYE

#### EINSTEIN'S MEASURE

## General Relativity as a Cosmic Ruler

▶ If you thought that general relativity had few practical applications in astronomy, think again. British and American radio astronomers have used Einstein's theory as a measuring rod to determine the distance of a binary pulsar from Earth with unprecedented accuracy. "This method is much more accurate than the usual way to find pulsar distances," says

**The thick smoggy haze that gives Titan an orange color may actually cool its surface, rather than heating it as first thought.**

NASA/JPL

Ed van den Heuvel, an astronomer at the University of Amsterdam.

Last January, at a conference on gravitational waves and experimental gravity in Les Arcs, France, Ingrid Stairs of the University of Manchester and David Nice, Steve Thorsett, and Joe Taylor of Princeton University described their timing measurements of PSR B1534+12, a binary pulsar in Serpens.

The orbital period of a binary pulsar (0.42073729933 days in the case of PSR B1534+12) slowly decreases as it loses energy: The accelerating masses emit gravitational waves according to Einstein's theory of general relativity. The discovery of this effect in the first binary pulsar, PSR B1913+16, earned team member Taylor and his research student Russell Hulse the 1993 Nobel prize in physics.

However, to check the pulsar-timing measurements against the theoretical predictions, a

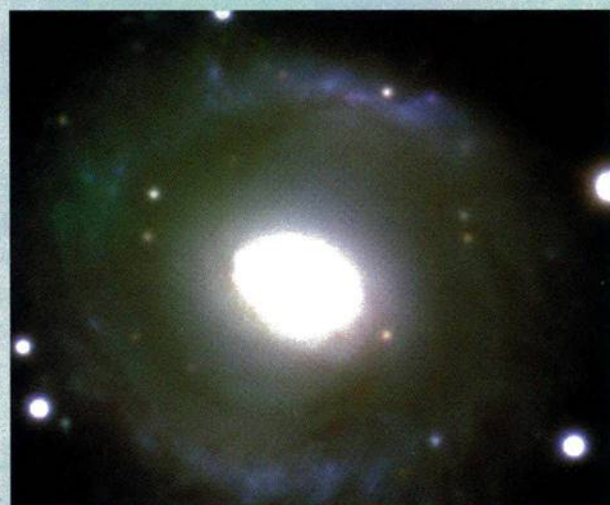
correction must be applied for the relative acceleration of the sun and the pulsar due to their respective motions through the Milky Way Galaxy. This correction depends on the pulsar's distance from Earth, which is uncertain.

Stairs and her colleagues turned the formula around. Assuming general relativity correctly describes the binary pulsar's orbital decay, they estimate the so-called galactic-kinematics correction, and from that estimate

they deduce the pulsar's distance from Earth.

The astronomers determined a distance of 3,520 light-years. Earlier measurements, based on the observed dispersion of the radio pulses by interstellar electrons, placed the pulsar between 1,500 and 3,000 light-years away. "It's a very interesting result," says van den Heuvel, "but unfortunately, the technique only works with binary pulsars, of which only three are known." — GOVERT SCHILLING

#### SPIRAL GALAXY



**THIS PHOTO OF SPIRAL GALAXY ESO 269-57, located in the southern constellation Centaurus at a distance of about 150 million light-years, was recently taken by the second 8.2-meter telescope installed at the European Southern Observatory's Paranal Observatory in northern Chile. Other galaxies were observed at about the same distance and direction as ESO 269-57, which form a loose cluster. There also are fainter, more distant galaxies in the background. The 269-57 designation refers to the ESO/Uppsala Survey of the Southern Sky in the 1970s during which more than 15,000 southern galaxies were catalogued. ESO 269-57 is a tightly bound type Sa object. The "r" refers to the "ring" that surrounds the bright overexposed galactic center. This photo is a composite, based on blue, yellow-green, and red exposures taken March 28, 1999. The image quality is 0.7 arcsecond, and the field is 90 by 90 arcseconds.**

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BINARY STAR

## Star's Hot Wind Fans into Spiral

► Astronomers at the University of California at Berkeley have found a star with the shape of a galaxy. The spiral-shaped star, named Wolf-Rayet 104, or WR 104, was discovered using the Keck I Telescope in Hawaii. Scientists used a technique called aperture masking interferometry to view the star's dust. William Danchi of UC Berkeley's Space Sciences Laboratory says, "This is the first time anyone has gotten any detail of a dusty Wolf-Rayet star." WR 104 is 4,800 light-years away, in the direction of Sagittarius, too far away to be viewed by astronomers with conventional telescopic imaging techniques.

The spiral star is actually two stars, a Wolf-Rayet star and a luminous, blue OB star, orbiting each other. The Wolf-Rayet star is three times larger, 25 times heavier, and 10,000 times brighter than our sun. The incredible brightness causes the strong radiation field around the star to drive its

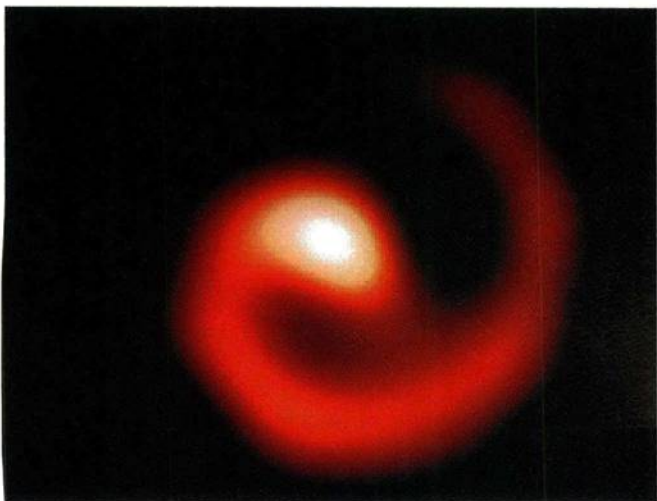
outer atmosphere into space, creating a dense, high-velocity wind. This dusty wind has puzzled astronomers because the radiation is so intense it should have incinerated the dust almost immediately.

Researchers believe they know how the dusty spiral maintains itself: Both the binary stars have strong stellar winds, which, when they meet, form a shock front. Peter G. Tuthill, also at UC Berkeley, says that the dusty material finds shelter in this cocoon, shielded from the direct glare of the stars.

The spiral shape the dust makes is a result of WR 104's orbital motion. The dusty wind blows straight out from the star, but its rotation, when seen from above, causes the dust to trail around the stars in a spiral shape. The astronomers compare this to a lawn sprinkler, whose spinning motion causes the water to spray out in a coiling pattern. — KERRY WHITT

**This newly imaged binary star, Wolf-Rayet 104, exhibits an unusual spiral structure.**

William Danchi, University of California Berkeley Space Sciences Laboratory/W.M. Keck Observatory



## Lunar Core Supports Collision Theory

NASA's Lunar Prospector spacecraft has confirmed that the moon has a small core, which supports the theory that an object the size of Mars collided with Earth and ripped away material that eventually formed the moon. "This is a critical finding in helping scientists determine how the Earth and moon formed," says astronomer Alan Binder. For the complete story, go to <http://www.astronomy.com/horizon.html>.



NASA, JPL

## NASA Replacing Hubble's Gyroscopes

Three of the Hubble Space Telescope's six gyroscopes are needed to precisely point the telescope at its targets, but two of them have failed and one is acting abnormally. Space Shuttle astronauts will replace the gyroscopes in October. For the complete story, go to <http://www.astronomy.com/horizon.html>.



NASA

## Andromeda Has Stellar Traffic Jam

Astronomers have obtained the clearest view yet of the center of the Andromeda Galaxy, the nearest galactic neighbor to our Milky Way. What they've learned may explain why this massive collection of stars, gas and dust seems to have two points of brightness in its nucleus. For the complete story, go to <http://www.astronomy.com/horizon.html>.



Jerry Lodrigus

## Brightest Ever Burst Observed

A recently discovered extraordinarily bright cosmic gamma-ray flash turns out to be the most energetic one yet measured. "It would be very hard to explain by most current theories," says Caltech astronomy professor Shrinivas Kulkarni.

"It was ten times more luminous than the brightest burst seen to date, and that was quite unexpected. If the gamma rays were emitted equally in all directions, their energy would correspond to ten thousand times the energy emitted by our sun over its lifetime thus far, which is about 5 billion years," says Caltech astronomy professor S. George Djorgovski, another of the principal investigators on the team. For the complete story, go to <http://www.astronomy.com/horizon.html>.



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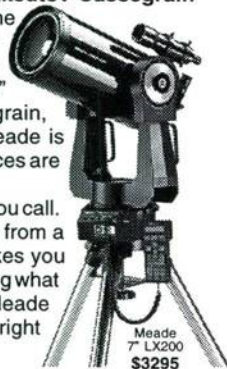


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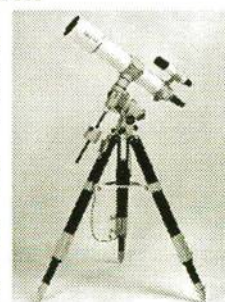
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Bushnell  
Voyager 6  
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The **6" f/8 Voyager Dobsonian**, shown to the left, has an *all-metal tube*, a 25mm eyepiece, a 6 x 30mm finder, and is priced at **only \$319**.

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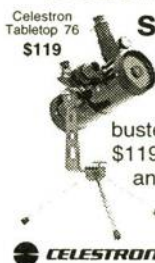


Bushnell  
Voyager 4  
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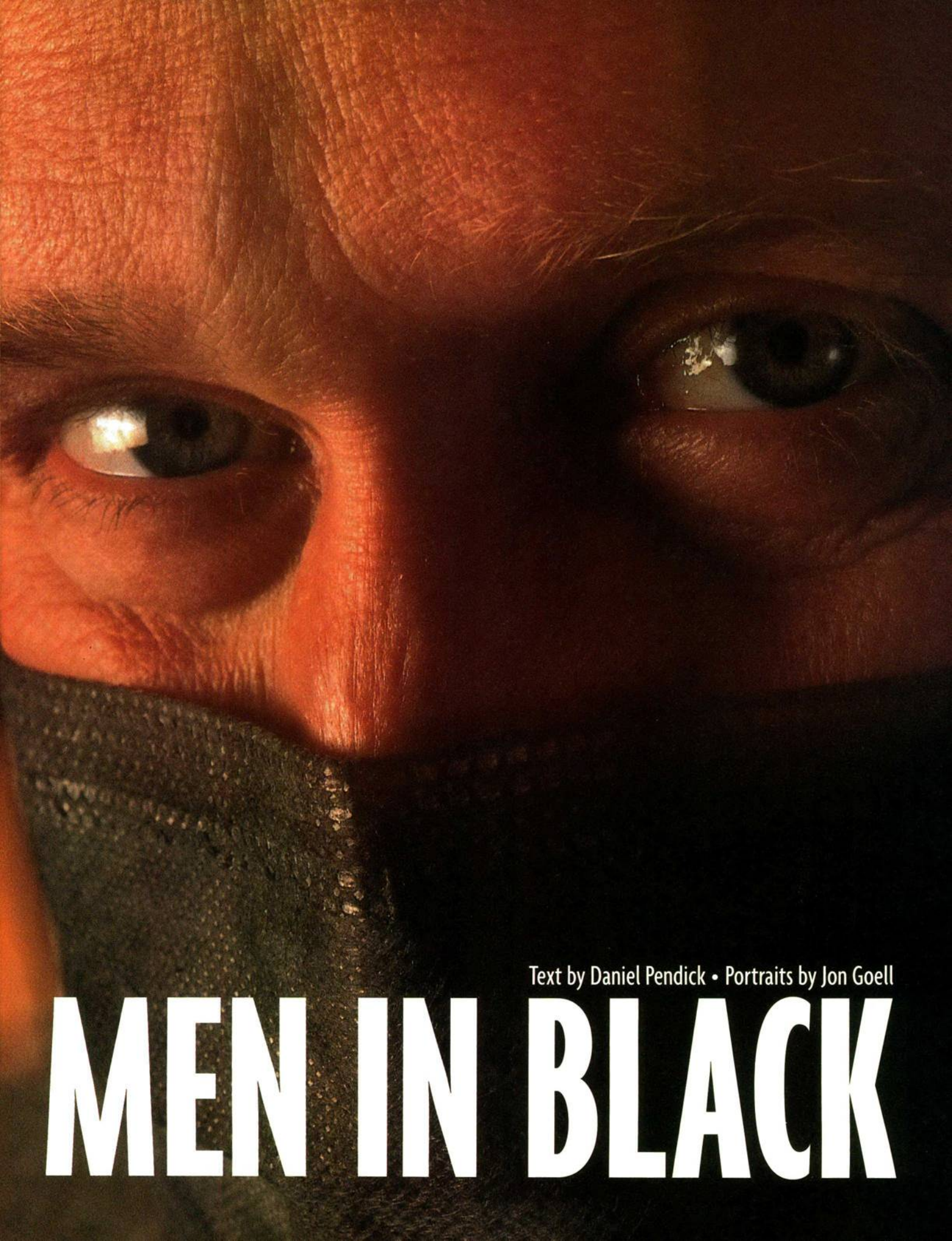


If Mars attacks, the martians  
won't be humanoids with ray guns —  
they'll be killer microbes.

Who will protect us?

**THE REAL**





Text by Daniel Pendick • Portraits by Jon Goell

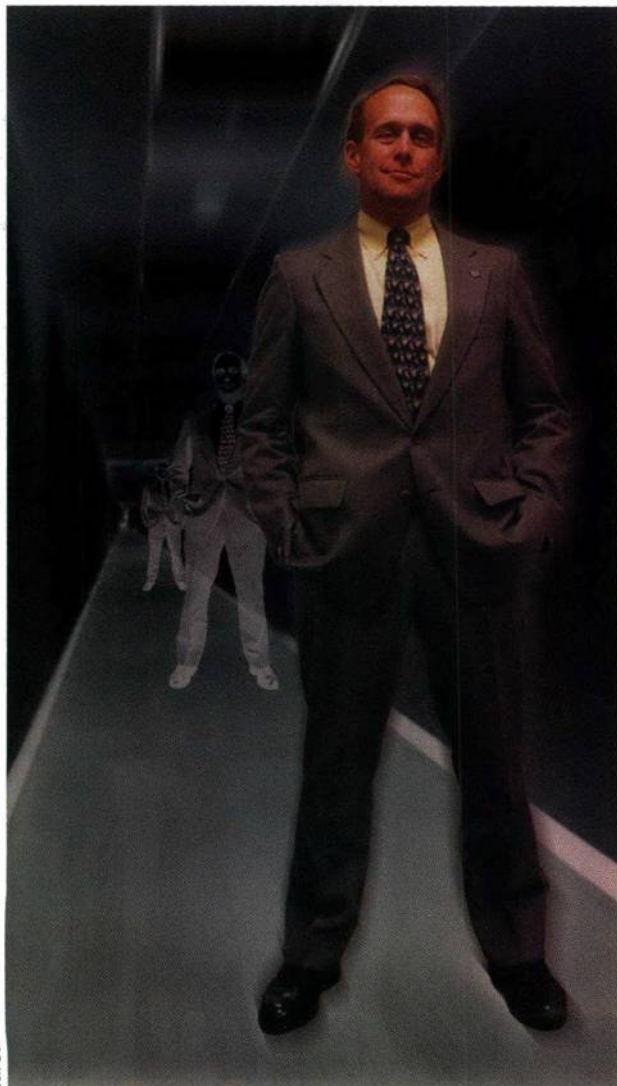
# MEN IN BLACK



Who will protect us from the martians? In the Hollywood account, that task lies with the Men in Black, an ultrasecret corps of dourly dressed men (and women) who make sure that space aliens don't cause trouble on Earth. But in real life, it's up to biologist John Rummel — NASA's Planetary Protection Officer — who works at NASA headquarters in Washington, D.C. It's a big job for one person, considering that his jurisdiction spans the entire solar system. Whenever NASA sponsors a mission that could bring back hazardous material from other worlds, Rummel makes sure the agency has a plan for protecting Earth. "And once I approve the planetary protection plan," says Rummel, "I make sure NASA actually follows it."

In coming years, Rummel's attention will be drawn to one place in particular: Mars. NASA's first sample-return mission to the Red Planet could blast off as soon as 2005 and return three years later. With a pound of martian rocks and soil in hand, scientists hope to tackle the unsolved mysteries of Mars, including its geological history and whether it once harbored life — or still does.

**NASA's John Rummel has the unenviable task of protecting Earth from martian microbes. "Once I approve the planetary protection plan," he says, "I make sure NASA actually follows it."**



Jon Goell



Rummel isn't worried about the monster bugs of Hollywood's *Men in Black* but rather microbial bugs that are potentially much more troublesome. The last thing NASA wants to set off is a pandemic of the martian flu that slaughters humans like cattle or a planetary infection of voracious bacteria that laughs at antibiotics and runs amok through our forests and fields.

How likely is this *Andromeda Strain* scenario? Not very, according to a panel of biologists and space scientists convened in 1997 by the National Academy of Sciences (NAS) in Washington, D.C., to assess the hazards of a Mars sample-return. On the other hand, "The risk is not zero," the panel unanimously agreed. "Samples returned from Mars by spacecraft should be contained and treated as though potentially hazardous until proven otherwise."

## Planetary Quarantine

Martian invasions were once the exclusive province of novelists. But fact caught up with fiction in 1957 when Sputnik reached orbit. A few months later, biologist and Nobel laureate Joshua Lederberg began to alert the scientific community to the potential risks of cross-contamination between worlds. As NASA prepared to land astronauts on the moon, the United States signed the Outer Space Treaty, which required spacefaring nations to explore solar system bodies "so as to avoid their harmful contamination and also adverse changes in the environment of Earth resulting from the introduction of extraterrestrial matter."

NASA made at least some effort to comply. When Neil Armstrong and his fellow Apollo 11, 12, and 14 explorers returned to Earth, they greeted their families through the windows of a quarantine tank and remained there for up to three weeks.

But according to Elliott Levinthal, an emeritus professor of physics at Stanford University who sat on the panel that supervised the planetary quarantine for the Apollo moon missions, flight controllers allowed two important lapses in quarantine that could have allowed lunar organisms to escape. Deferring to the safety of the astronauts, a vent was opened during re-entry to cool the cabin, and after splashdown a hatch was cracked so astronauts could exit their capsule. Not that NASA considered this particularly reckless: Most scientists thought the chance of finding organisms on the moon was practically zero.

"There were strict guidelines, but because nobody really believed there was a risk, the guidelines were ignored," Levinthal says. He fears that in its haste to search for life on Mars, NASA will retrieve samples before scientists are really capable of determining if they contain hazardous organisms. "I'm quite concerned," he



# *not zero."*

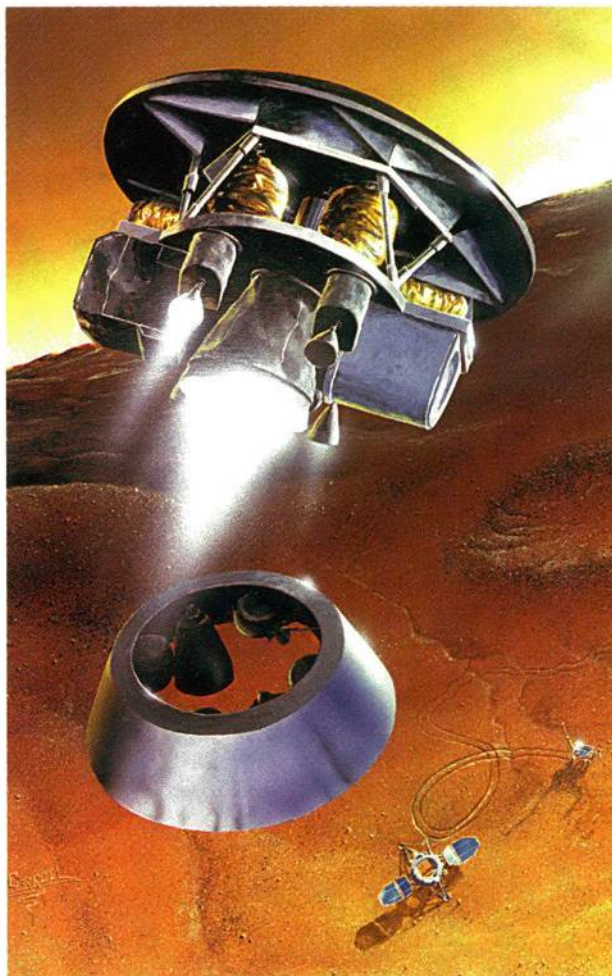
says. "NASA has been paying more attention than in the past, but they have a ways to go."

Fortunately, Levinthal's worst fears were not realized. In NASA's Lunar Receiving Laboratory, built at a cost of \$100 million (in 1996 dollars), scientists injected moon dust into mice and birds; they fed it to cockroaches; they sprinkled it onto plants and aquarium fish; they inoculated cultured monkey cells. Nothing happened.

In 1976, Viking 1 and 2 touched down on Mars and conducted a series of biology experiments that convinced many scientists that Mars is dead. The Viking landers set down on a landscape that was parched, frigid, and zapped by cell-busting solar ultraviolet radiation. The experiments yielded results that indicated the existence of soils laced with oxidizing chemicals that would tear apart organic molecules, which explains why the experiment that looked for organic molecules found none to a level of one part per billion.

But Mars might not be as hostile to life as we think. "It's nasty, there's no doubt about that," says Ben Clark, an NAS panel member from Lockheed Martin Astronautics in Denver, Colorado. "It's just that organisms are extremely resourceful." And the Viking experiments, Clark adds, did not prove for certain that the martian surface is sterile. "There are plausible scenarios in which a sample returned from Mars could contain living organisms, either active or dormant," Clark and the other panel members concluded. The chances of finding life would only increase, many believe, if future sample-returns drilled beneath the surface into hot springs or other potential refuges for life.

**Welcome home.** Due to concern about lunar microbes, Apollo 11 astronauts Neil Armstrong, Michael Collins, and Buzz Aldrin spent three weeks in quarantine upon their return to Earth.



**If all goes according to plan, an ascent vehicle carrying rock and soil samples will blast off from the surface of Mars in 2006. NASA will take extraordinary precautions to make sure any martian microbes won't cause havoc when they are returned to Earth.**

## A Bug-Proof Mission

Mindful of the potential hazards of sample-return and the fears it could instill in the public, NASA, under Rummel's watchful eye, has kicked off the process of designing the most bug-proof mission imaginable. While the design for a sample-return mission won't be finalized until next year, engineer Mark Adler and his colleagues at the Jet Propulsion Laboratory in Pasadena, California, have come up with some ideas for how to bring the samples back in a clean, tightly sealed container.

Here's the current plan: NASA will launch a lander-rover pair in 2003 and 2005. Each rover will collect about one pound (500 grams) of rock and soil, enough to fill an empty soda can. The rovers will deliver the samples to 5.5-inch-wide (14 cm) spherical containers inside each lander. Each lander comes with a three-stage rocket called the Mars Ascent Vehicle (MAV). The sphere is built and tightly sealed inside the nose cone of the MAV such that it is never exposed to the martian surface.

The critical thing is sealing the container so tight that it won't spring any leaks on the journey home or during its descent to Earth's surface. Adler reckons welding would be the best way. That could be done by igniting



## MARTIAN SUPERBUGS?

Assuming Mars has microbial life, could an organism that evolved on Mars cause any mischief on Earth? There is wide agreement that the chance of finding disease-causing organisms is negligible. "I think the argument can be made that whatever's adapted to the martian environment isn't going to thrive in the human gut," says Rita Colwell, a leading microbiologist who was recently appointed head of the National Science Foundation. Martian bugs probably wouldn't measure up against their terrestrial counterparts, either. Ordinary soil shelters thousands of species of microorganisms, each finely tuned to different nutrients and conditions. "It's really hard to imagine some kind of 'superbug' being able to come in and mess that up," says microbiologist Kenneth Nealsen, who chaired the NAS panel.



Dee Bieger/Lamont-Doherty Earth Observatory

Will martian bugs slaughter terrestrial plants and animals? In this case, the terrestrial fungus *Ustilago violacea* (red balls) is infecting a terrestrial plant, white campion.

Hard to imagine, but not impossible. If biologists have learned anything, Colwell says, it's that life is in the habit of confounding scientists' expectations. Until the mid-1950s, she recalls, many thought that the deepest reaches of the oceans were devoid of life, until deep-sea submersibles proved otherwise. Then in 1977, thriving oases of life were discovered around deep-ocean hydrothermal vents. More recently, scientists were stunned to find bacteria living several miles below Earth's surface.

University of California at Berkeley microbiologist Norman Pace says it's conceivable that a particularly adaptable martian bug could nuke its terrestrial brethren and take over their homes. "All organisms out in the real world are duking it out," Pace says. "The chemical defenses are rampant. If an organism came in that had a better competitive strategy — for example it might make an antibiotic that could knock off terrestrial lifeforms — it could take over their niches." Or, the invaders could simply be much better at using a particular resource and eat the natives out of house and home. That could have effects on the plants and animals higher up the food chain, including us. All this, Colwell agrees, is "within the range of possibility of microbial ecology."

strips of pyrotechnic material — similar to the stuff in the explosive bolts that separate rocket stages — to seal the seam between the container and its lid.

While the spherical container is clean, the outside of the MAV has been exposed to the martian surface. Unfortunately, NASA can't rely on the cold, vacuum, and radiation of space to nuke any bugs clinging to the dust grains. Spores — the case-hardened, dormant form of bacteria and fungi — can easily survive the nine-month journey to Earth. Indeed, when Apollo 12 astronauts returned to Earth with a camera removed from the Surveyor 3 lander, bacteria were found in its foam insulation — still viable after 2½ years on the moon.

To maintain stability, the MAV will spin as it heads into space. But this spin has an additional benefit: Centrifugal forces will prevent martian dust on the outside of the MAV from migrating inward to the spherical container. The first two stages, which have been contaminated by martian dust, eventually fall back to Mars's surface. Only the third stage, which is kept clean, will make it into orbit, where it will hand the samples off to a return vehicle provided by the French Space Agency. "The only thing that gets into Mars orbit is stuff that's completely clean," says Adler. "The stuff that is dirty crashes back onto Mars."

Once the return ship reaches Earth, it has to land the container without it cracking open. Adler says that the option least subject to Murphy's Law is to drop the container directly into the atmosphere in a re-entry capsule filled with a stiff foam spun out of carbon. On descent, atmospheric drag on the hardened, heat-resistant surface of the puffball (there's no need for a parachute) slows the capsule from 27,500 miles an hour to about 70 miles an hour. Then — thud! — it hits the ground and the foam absorbs the shock.

The impact of the capsule marks the beginning of one of the riskier phases of the mission: isolating the samples and making sure they don't contain hazardous organisms. In June 1997, NASA convened a few dozen experts to recommend how to do that. The agency tapped biologists from academia and experts in biosafety from the Centers for Disease Control and Prevention (CDC), the Environmental Protection Agency, and even Fort Detrick, the Army's center for research on biological warfare agents.

The samples will be scrutinized in a microbial Fort Knox of the type used to study the most deadly organisms on Earth. If there's anything squirming inside the samples, Rummel is confident they won't be doing any sightseeing on Earth. After technicians in sealed "moon suits" check the sample capsule for leaks, it will be taken to a secure laboratory. The panel recommended strict containment comparable to the level of security the CDC uses for deadly organisms for which there is no vaccine or treatment — the Ebola virus, for instance. "The conservative approach is based on the panel's recommendation that the samples should be treated as hazardous, even though the likelihood of anything being infectious or harmful is very low," says Rummel.

Samples will be studied in a sealed glove box kept at a slightly lower air pressure than the laboratory itself; the laboratory as a whole would be at a slightly lower pressure than the outside world. This way, if anything springs a leak, the flow of air — and microbes — is always inward.



## Looking for Life

Determining whether the samples contain living organisms could prove to be the greatest challenge of the mission. Rummel points to the case of the martian meteorite ALH84001 and the continuing debate over whether it contains traces of life. "What's been detected there may or may not have something to do with life on Mars," he says. "But it has illustrated very profoundly our real ignorance about evidence of living organisms."

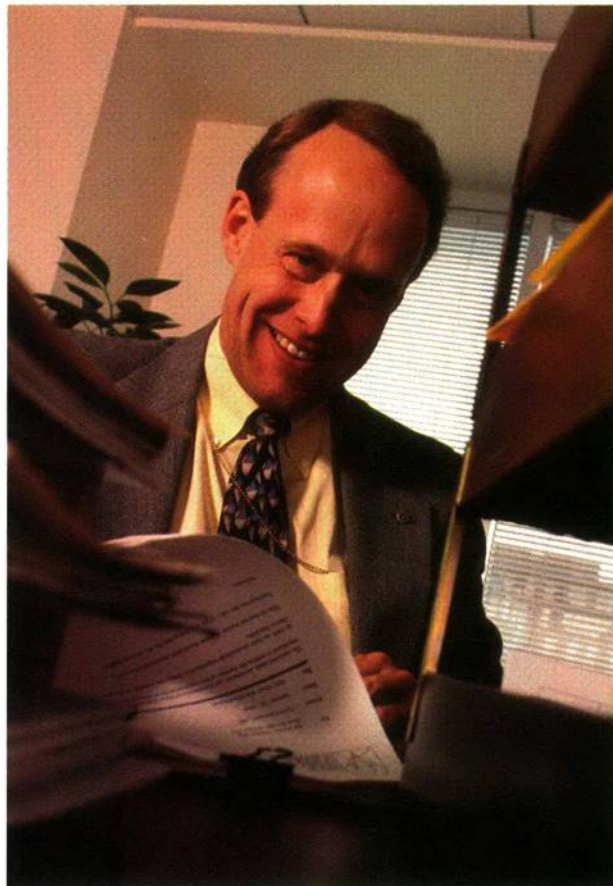
Not that biologists are completely clueless. There are powerful techniques that can search the samples virtually molecule by molecule for traces of life. But even if such traces were found, NASA would still have to figure out if the organisms were alive or merely a fossil smudge. This could be tricky. To detect signs that an organism is metabolizing bits of its environment and converting it into energy, they'd have to give the bugs the right food and conditions. "Almost all the techniques that we use rely on the fact that a specimen is earthlike," Levinthal says. "If there was a form of super-simple life of which we were ignorant, how the hell would you ever find it?"

Rummel points out, however, that if NASA brings the samples back in 2008, as currently planned, it will have technology almost a decade more advanced than today's. And today's is still pretty good, says Rummel. "I am confident that, even with the technology we have today, we can detect life if it exists or existed in a returned Mars sample."

Levinthal emphasizes that he is just as eager to get samples back to Earth as anyone. He just wants to avoid a repeat of the Apollo experience, when mission goals overruled planetary quarantine. "If you are too extreme you will make no progress," he says. "There is a certain level of risk. The question is whether you've been really diligent or if you've been in a greater hurry than you need to be."

If skeptical insiders such as Levinthal don't keep NASA's planetary protection police in line, fear of lawsuits and picket lines certainly will. Margaret Race, a former Berkeley ecologist, says a lot has changed since Apollo. In those days, decisions about planetary protection were

**If NASA brings back signs of past or present martian life, could scientists even recognize it as such? The ongoing debate about possible fossilized microbes in Mars meteorite ALH84001 illustrates humanity's ignorance of extraterrestrial life.**



Jon Goell

**John Rummel may look casual to someone passing by his office, but he stresses, "We're not casual about protecting Earth."**

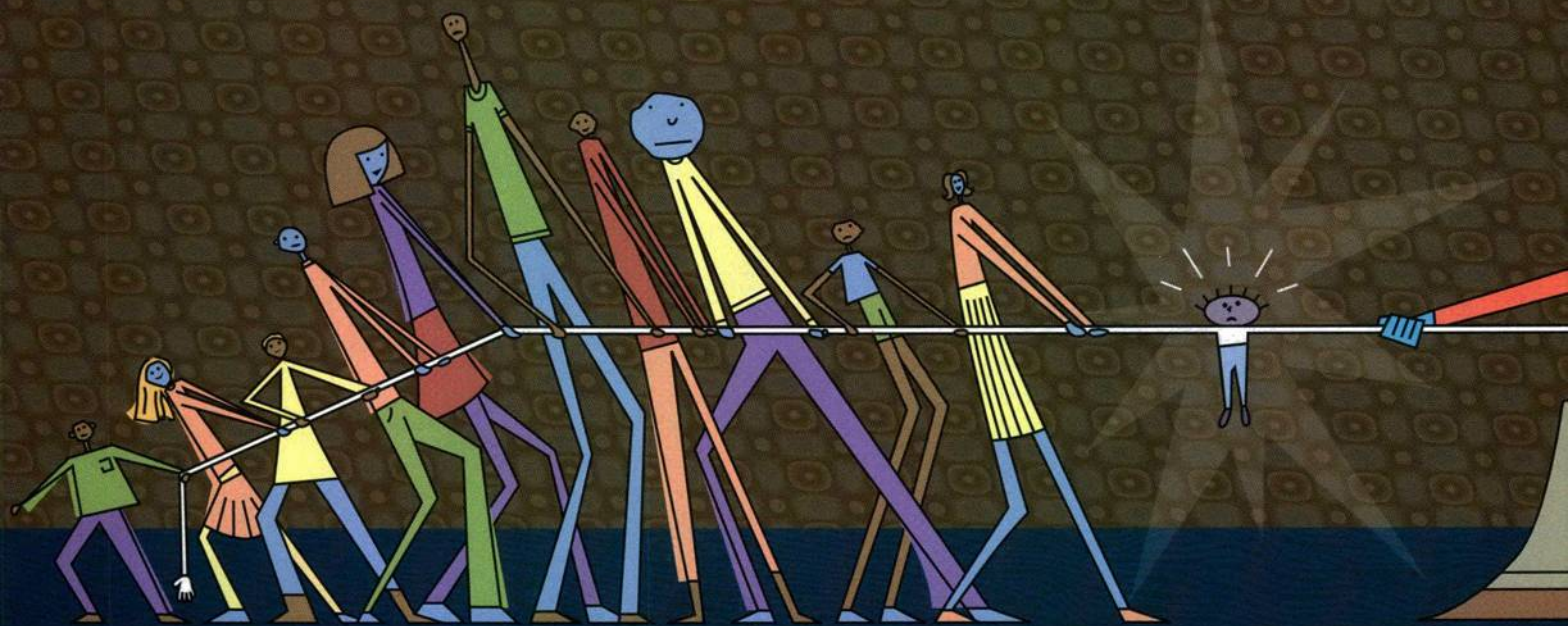
made behind closed doors. "But that was before the Environmental Protection Agency, environmental impact statements, environmental law, and Three Mile Island," says Race. Before the sample-return mission can get off the drawing boards, NASA has to submit an environmental impact statement detailing all the possible risks of sample-return and what will be done to minimize them.

Former NASA planetary protection officer Michael Meyer hopes that in the end the public will weigh the potential hazards of sample-return against the benefits. With fresh martian soil, we could actually discover life elsewhere in the solar system — a finding that could fundamentally change our understanding of life on Earth. "It's possible that there's something out there we haven't conceived of yet," Meyer says. "But if you follow that argument, there are so many things you would never do. You would just go hide in your room."

Besides, Rummel and his team will be watching when the first can of Mars is cracked open. And if anyone happens to be wearing dark sunglasses like the bug hunters in *Men in Black*, Rummel promises they won't be rose-tinted with regard to the potential hazards of sample-return. As Rummel puts it, "We're not casual about protecting Earth." **A**

*Daniel Pendick is a freelance science writer based in Massachusetts. The only superbugs he ever had to contend with were the roaches in his former Milwaukee apartment building.*





# *Is* Pluto *a* Pla

Pluto has a public-relations problem. The smallest, most distant, and most anomalous planet in our solar system is an ice-covered David overshadowed by larger, flashier Goliaths. Pluto is like neither the four inner terrestrial planets, nor the four gas-giant planets farther from the sun. To make matters worse, new discoveries have led astronomers to agree that what for 70 years has been our ninth planet bears surprising similarities to dozens of diminutive, cometlike objects recently found beyond Neptune in the so-called Kuiper Belt.

Pluto's low point came in late 1998 and early 1999. That's when astronomer Brian Marsden of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts,

proposed a dual designation for Pluto as a planet and a "minor planet." "If Pluto were discovered today instead of 70 years ago, it would be considered a minor planet and given a minor planet number," says Marsden, director of the International Astronomical Union's (IAU) Central Bureau for Astronomical Telegrams and the Minor Planet Center.

Marsden may be correct. However, the IAU, which is responsible for naming and classifying all astronomical objects, came to Pluto's rescue after many journalists interpreted Marsden's proposal as a pending, fait accompli "demotion" of Pluto. The organization issued a February news release stating that Pluto was in no imminent danger of





Astronomy: Terri Field

# net?

*Seventy years after Clyde Tombaugh discovered our ninth planet, an emotional debate erupts over a proposal to demote it.* **by Rex Graham**

a dual-classification demotion. The release states, “No proposal to change the status of Pluto as the ninth planet in the solar system has been made by any division, committee, or working group of the IAU responsible for solar system science. . . . The Small Bodies Names Committee (of the IAU Division of Planetary Systems Sciences) decided against assigning any minor planet number to Pluto.”

Marsden’s proposal also failed to win the support of many individual astronomers. After all, “minor planet” is an IAU term often used interchangeably with “asteroid,” and virtually all astronomers agree that Pluto is no asteroid. “Marsden’s idea makes no sense,” says Robert Millis, director of the

Lowell Observatory in Flagstaff, Arizona, where Clyde Tombaugh discovered Pluto in 1930. “Why call Pluto fish and fowl? We take a fair degree of pride in this object. It deserves to be considered something more than a minor planet.” He adds rhetorically that if Pluto is demoted, a reduction in rank might also be considered for Mercury. “It has no atmosphere, no satellite,” he says. “It’s just a dead chunk of rock.”

University of Maryland astronomer Michael A’Hearn, who serves as president of the IAU’s Planetary Systems Sciences Division and chair of its Small Bodies Names Committee, has become weary of moderating numerous discussions over Pluto’s standing and how to define a planet.





Astronomy: Kellie Jaeger/Images by NASA/JPL

"The debates have been remarkably emotional," says A'Hearn. "What does it tell me? It tells me that scientists are less rational than I thought they were."

S. Alan Stern, a planetary scientist in Boulder, Colorado, with the Southwest Research Institute, says the Pluto fuss has taken on a self-perpetuating life of its own. "I've heard all these fanciful arguments throughout this debate about why Mercury should be tossed out, Mars is really an asteroid, Jupiter is a star, and the moon should really be called a near-Earth object," says Stern. He says the whimsical proposals are humorous, but they conceal a stronger countervailing consensus developing among planetary astronomers: More, not fewer, objects should be listed as planets in our solar system. For example, Stern and Millis argue that large spherical asteroids should be added to the list of planets. "How many planets are in the solar system?" asks Stern. "By the best definition of 'planet' I know of, it is a dozen and climbing. And most planetary astronomers agree that we will eventually find hundreds of objects larger than Pluto in the Kuiper Belt, possibly some Earth-sized objects." All those large objects should be categorized as planets, he says.

## The Search for Planet X

Well before Marsden's minor-planet proposal, Pluto was a misunderstood planet. Several 19th-century astronomers, particularly Percival Lowell, thought the gravitational tug of an unknown "Planet X" was perturbing Neptune. Lowell, an imaginative astronomer, also said there were "canals" on Mars, and he deduced from that mistaken idea that Mars is home to an alien civilization. Eager to find Lowell's predicted planet, Lowell Observatory hired Clyde Tombaugh in 1929.

Tombaugh, the 23-year-old son of a Kansas farming couple, had earned a reputation as a talented amateur astronomer. The observatory offered him a starting salary of \$90 a month. Luckily for Lowell, Tombaugh was eager to leave farm work for the physically demanding, bone-chilling job that was his first love. Using a 13-inch refractor, Tombaugh took pairs of photographs of the night sky —

**Pluto is smaller than the rest of the planets, indeed more diminutive than seven of the solar system's moons, including Earth's. On the other hand, it beats out every one of the more than 10,000 known asteroids.**

separated by a time interval of two to six days. He examined each pair simultaneously through a microscope that "blinked" back and forth from one image to the other. With the blinking technique, background stars remained stationary, but nearby objects — planets, comets, and asteroids — appeared to move. Unfortunately, Tombaugh's plates were full of moving asteroids. However, he realized that the farther away a given object was, the less it would move. He focused his attention on the less mobile objects and discovered a dim 15th-magnitude starlike image, Pluto, within a year.

"When Tombaugh found it, people at Lowell were predisposed to call it a planet because that was what they were looking for," says Philip D. Nicholson, an astronomer at Cornell University and editor of *Icarus*, a journal on planetary astronomy. "At the time, nothing else had been discovered in the outer solar system."

Astronomers originally estimated that Pluto contained the mass of 11 Earths, however, it shrank with each new observation. "Its estimated mass dropped alarmingly over time," says Alexander Dessler, an emeritus astronomer at the University of Arizona. "We plotted the mass of Pluto as it was revised downward over time, and we jokingly predicted in a paper that it would disappear by about 1990."

Despite the uncertainties, Pluto's discovery marked the beginning of the golden age of American astronomy. Swept up in the 1930s excitement, pioneer animator Walt Disney created a cartoon dog for Mickey Mouse and named it Pluto. Pluto the planet was eventually measured to be one five-thousandth the size of astronomers' first estimates, and the appeal of the cartoon dog declined with the planet's size. Pluto was the only Disney character not included in the 1984 reunion feature titled "Mickey's Christmas Carol."

E. Myles Standish, an astronomer at NASA's Jet Propulsion Laboratory, showed in 1993 that the perturbation on



Neptune that Lowell based his Planet X theory on actually was a mathematical artifact. Standish demonstrated that by using the most up-to-date measures of the masses of the jovian planets, primarily those of Neptune, the orbital perturbations calculated by Lowell vanished.

## Cold, Hard Facts

Pluto is not the only solar system object to face demotion. In 1801 Giuseppe Piazzi found Ceres moving across Taurus between Mars and Jupiter. He said Ceres was a planet. During the following six years, astronomers found three slightly smaller objects in Ceres's vicinity. Vesta, Juno, Ceres, and Pallas were massive enough that their gravity molded them into spheres, and all four were dubbed planets. They were soon demoted to asteroid status, but even as late as 1847 a textbook written by Denison Olmsted titled *An Introduction to Astronomy* listed 11 planets in the solar system: Mercury, Venus, Earth, Mars, Vesta, Juno, Ceres, Pallas, Jupiter, Saturn, and Uranus. However, Vesta, Juno, Ceres, and Pallas soon lost their status with the discovery of hundreds of smaller objects in what is now called the asteroid belt. The largest of these objects are what Stern, Millis, and other planetary astronomers favor for a return to planetary status.

Pluto is about 1,500 miles (2,400 km) in diameter. That is larger than the largest asteroid, Ceres, which is 580 miles (933 km) in diameter, but smaller than the moon and Mercury. With a density of 2 grams per cubic centimeter, astronomers estimate that Pluto is roughly 60 percent rock and 40 percent ices of frozen nitrogen, carbon monoxide, methane, and water. NASA is planning the Pluto-Kuiper Express mission for a launch in 2004 to photograph and study Pluto in detail.

Pluto's ices vaporize to produce a thin atmosphere when the planet is near its perihelion, or closest distance to the sun, of 2.8 billion miles (4.4 billion km). In fact, for 20 years of its 248-year orbit, Pluto is closer to the sun than Neptune, one of several features that makes it unique among the planets. On February 11, 1999, Pluto moved beyond Neptune's orbit toward its aphelion, or farthest distance from the sun, of 4.6 billion miles (7.5 billion km). By then nearly all Pluto's atmosphere will have refrozen and dropped to the surface as frost. Pluto orbits the sun two times for every three orbits that Neptune makes. This orbital resonance allows Pluto to cross the orbit of Neptune but never collide with it.

Pluto's inseparable dance partner is its satellite Charon. Icy Charon is half Pluto's diameter and one-tenth of its mass. Because of their relatively similar sizes, Pluto and Charon behave as a unique "double planet." They revolve around each other every 6.4 days at a near-constant distance. In their lock-step tango, Pluto and Charon constantly present the same hemispheric face to each other. The pair moves as if it is a "giant lopsided dumbbell spinning in space," wrote Anthony Dobrovolskis, Stanton Peale, and Alan Harris in the 1997 book *Pluto and Charon*. The dumbbell's orbit around the sun is highly inclined from the plane of the solar system — 17 degrees — another feature unique among the planets.

## Pluto's Neighborhood Gets Crowded

Astronomers David Jewitt and Jane Luu searched beyond Neptune for objects that astronomer Gerard Kuiper theorized must exist. Kuiper and others championed the idea that the solar system didn't end abruptly at Neptune and Pluto. They predicted that the region was home to a belt of icy objects left over from the formation of the solar system.

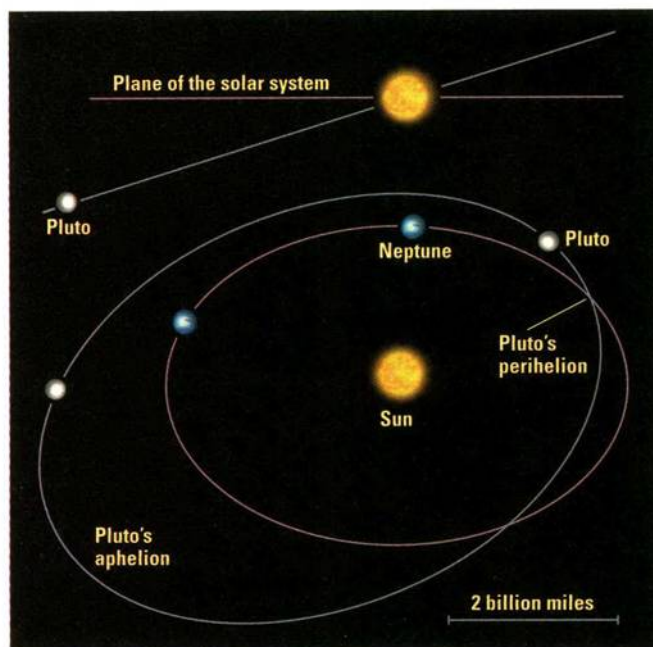
Using digital images obtained with the University of Hawaii's 2.2-meter telescope on Mauna Kea, Jewitt and Luu used a computerized version of Tombaugh's blinking technique. The improved telescope and computer enhancements allowed Jewitt and Luu to discover a very faint (22.8 magnitude) object in 1992 that appeared to move very slowly. The estimated 120-mile-wide (200-km) object was beyond Neptune, which is 30 times more distant from the sun than the orbit of Earth, or 30 astronomical units (AUs). The object, dubbed 1992 QB<sub>1</sub>, was a posthumous vindication for Kuiper. As of March 1999, astronomers have discovered more than 130 Kuiper Belt Objects (KBOs), an achievement considered the most significant since Tombaugh found Pluto in 1930.

Renu Malhotra, an astronomer at the Lunar and Planetary Institute in Houston, Texas, has developed a mathematical model that explains the behavior of the KBOs. Her model correctly predicted that many of the KBOs — like Pluto — would have 3:2 orbital resonances with Neptune.

Malhotra's model also indicates that as Neptune moved away from the sun billions of years ago, it scattered most objects in its path out to the Oort Cloud of comets that surrounds the solar system at very large distances. Neptune also "captured" objects in various ways. Triton, captured by Neptune as one of its moons, has the same density and composition as Pluto but is slightly larger. "Triton, a satellite, used to be a planet," says Stern, "but now it could be called a planetary body."

As Neptune continued to drift outward, Malhotra's model explains that it forced Pluto into an orbit inclined 17 degrees from the plane of the solar system. Her model predicts that other KBOs would have ended up in resonant orbits inclined similarly to Pluto's. Astronomers have found two KBOs with probable 2:1 resonant orbits, fulfilling another prediction of the model. Other more distant KBOs would orbit in the cold blackness of the distant solar system possibly out to 150 AU or farther.

**Pluto's elliptical orbit tilts 17° to the solar system's plane, more than any other planet's, and crosses Neptune's orbit. The two planets can't collide because they lie 240 million miles apart where the orbits cross.**



Astronomy: Kellie Jaeger



# BROWN DWARFS *vs.* PLANETS

When scientists try to lump astronomical objects into broad categories, Mother Nature just shakes her head. Consider the Pluto debate. Astronomers argue whether Pluto should be classified as a major planet, a minor planet, or an overgrown comet. But to Mother Nature, these classifications are purely artificial and arbitrary. In actuality, the solar system contains a continuum of objects ranging in size from tiny chunks of rock and ice to giant spheres made primarily of gas. Recent discoveries outside the solar system show that this continuum extends even further up the mass scale, all the way to the stars themselves, raising yet another thorny semantic dispute.

The lightest objects that are considered true stars contain about  $\frac{1}{12}$  the mass of the sun, or 80 times the mass of Jupiter. Below this mass threshold, gravity cannot squeeze the material in an object's core to a high enough temperature and density to ignite hydrogen fusion, the predominant energy source of stars.

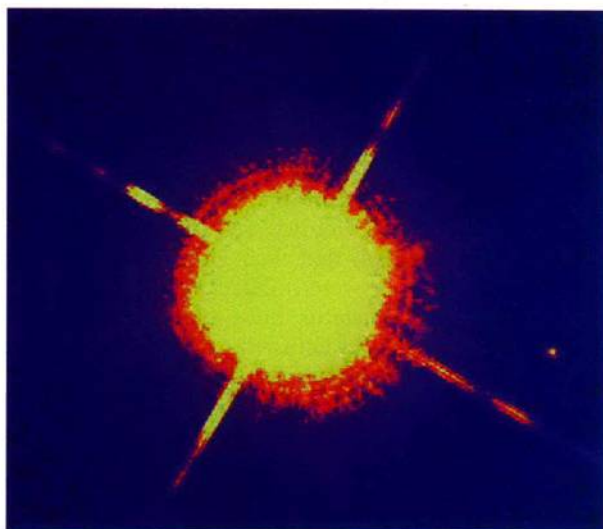
Until 1995, astronomers hadn't conclusively identified a single object with a mass between that of Jupiter and the wimpiest star. But knowing that Mother Nature prefers a continuum, most astronomers predicted that such objects would eventually turn up once the means to find them existed. Sure enough, in just the past four years, astronomers have found dozens of objects that fall squarely into this gap. Most of these objects are free-floating in space, unattached to stars. Astronomers call these failed stars "brown dwarfs." No argument here.

But what if one of these objects orbits a star? San Francisco State University astronomers Geoff Marcy and Paul Butler have discovered an object orbiting the star 70 Virginis that's at least 6.7 times the mass of Jupiter. Marcy and Butler call it a planet. Another group has found a faint companion to the star Gliese 229 that appears to have a mass between 20 and 55 Jupiters. They call this object a brown dwarf. But exactly where does one draw the line between planets and brown dwarfs?

In the traditional view, the distinction between planets and brown dwarfs is based on how they form. If a stellar companion with 10 Jupiter masses formed the way a star does, from a collapsing cloud of interstellar gas, it's a brown dwarf. If a 10-Jupiter-mass stellar companion formed by gradually accumulating gas and dust inside a circumstellar disk, it's a planet.

"The problem with this definition is that it's useless to an observer because you can't observe how something formed. So there's really no point in defining things that way," says Caltech astronomer Ben Oppenheimer, a member of the team that discovered the brown dwarf in orbit around Gliese 229.

Oppenheimer, along with a growing minority of astronomers, argues that brown dwarfs should be defined



Ben Oppenheimer (Caltech), et al., and NASA

**Although Gliese 229 ranks among the fainter stars, it nearly overwhelms its brown dwarf companion, Gliese 229B (at right).**

as objects containing between 13 and 80 Jupiter masses. Objects in this mass range can't fuse hydrogen, but they have enough mass to briefly ignite deuterium fusion in their cores (deuterium is a hydrogen atom containing one proton and one neutron, instead of just a single proton). Using this criterion, a stellar companion with less than 13 Jupiter masses is a planet.

But this definition fails to satisfy theorists such as Alan Boss of the Carnegie Institution of Washington, who simulates planet and star formation on computers. "You could have a 10-Jupiter-mass object, a 15-Jupiter-mass object, and a 100-Jupiter-mass object that all formed the same way. But one is a planet, one is a brown dwarf, and one is a star," he says. "That doesn't make any sense."

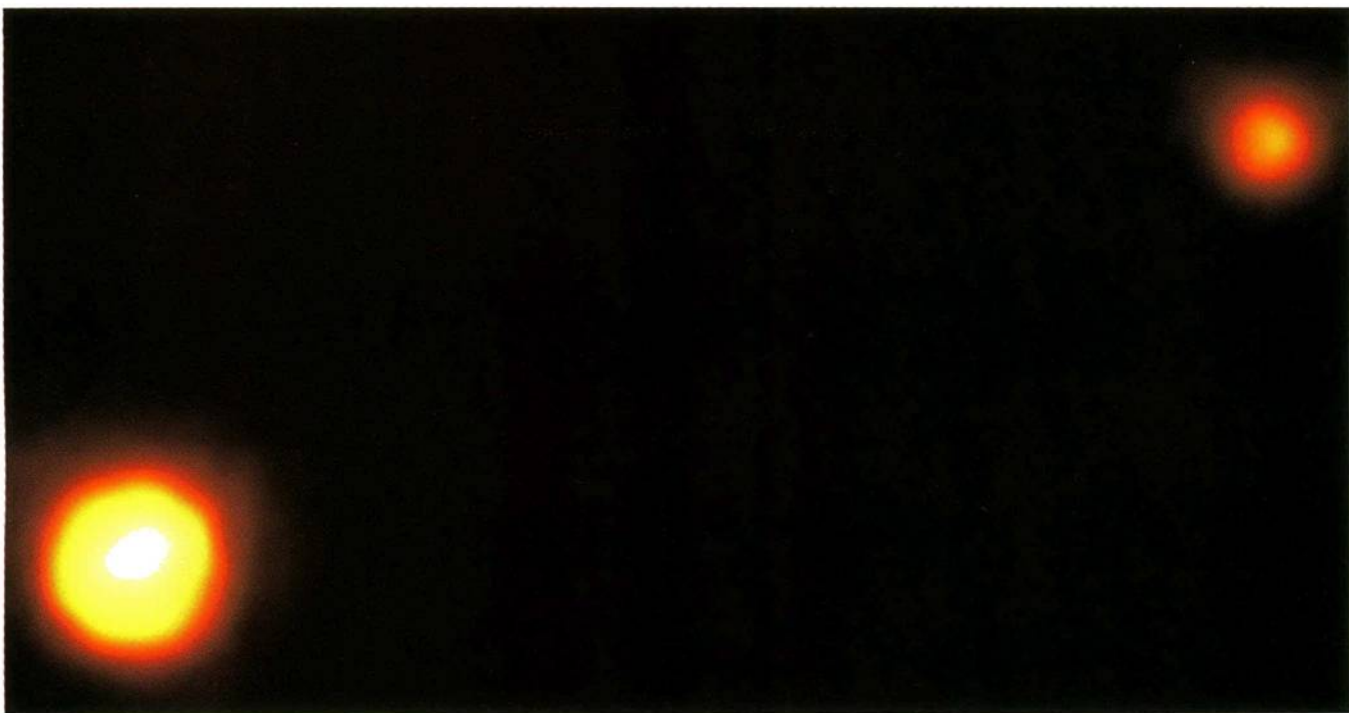
Geoff Marcy questions whether astronomers should even try to make a distinction between planets and brown dwarfs. "We all harbor prejudices based on the semantics we adopt. There might in fact be so many physical processes that form planets, and so many that form brown dwarfs, that it will become a mess to try to distinguish them. It's a little like trying to classify humans as happy people and sad people. Such pigeonholing blinds us to the true diversity that's out there."

But Oppenheimer strongly believes astronomers need to resolve this issue one way or the other. "You could take the point of view that all of this is just semantics, just playing around with words. But from another point of view, it's important to define these terms because otherwise people are talking about completely different things; it just confuses the whole subject."

In the meantime, Mother Nature just shakes her head.

— Robert Naeye





R. Albrecht (ESA/ESO) and NASA

Although no KBOs have yet been observed beyond 49 AU, Malhotra, Stern, Millis, Marsden, and most other planetary astronomers predict that thousands, and possibly millions, will almost certainly be found there. “We have only discovered the tip of the tip of the tip of the iceberg,” says Millis.

## What Is a Planet?

Marsden’s proposal to list Pluto as a minor planet has forced astronomers to try to agree on a modern definition of “planet.” The term “extrasolar planet” has appeared in the lexicon of astronomy to apply to bizarre “hot Jupiters” or “roasters” discovered orbiting nearby stars. About 20 such extrasolar planets have been found. In addition, “proto-planets” in infant solar systems; “rogue planets” that have been tossed from solar systems; “planetesimals,” or planet fragments that coalesce into real planets; and “planetary bodies,” which, like Triton, could have been planets at one time, have appeared in the astronomical vocabulary.

What is a planet? “It’s like pornography and art: It’s hard to define, but you know it when you see it,” says Dale P. Cruikshank, an astronomer with the NASA Ames Research Center in Moffett Field, California. Some astronomers suggest that a planet should be at least 1,000 kilometers in diameter, a hurdle that Pluto, but not Ceres, would clear. However, that standard was considered arbitrary and has failed to win wide support among planetary astronomers.

Stern envisions a “physics-based definition that traps planets in a testable set of circumstances.” By his definition, nothing could be classified as a planet if it is larger than a brown dwarf, a gaseous object with at least 12 times the mass of Jupiter (see opposite page). “Nobody wants things that do fusion to be planets,” says Stern. Nor could a planet be an object smaller than an irregularly shaped asteroid. “The lower size limit is, depending on what it is made of, a few hundred miles across,” he says. “It would be an object that is big enough for gravity to dominate its material strength so that it flows into a sphere.” Stern concedes that many objects would be candidates for planethood based on their size, but

**Pluto (lower left) and Charon are the closest thing to a double planet we know of, with Charon half Pluto’s size and just 12,200 miles from it.**

only those that also orbit a star would pass the second test. By this measure, the large Galilean satellites of Jupiter and “rogue planets” that have been ejected from a solar system would be called “planetary bodies,” but not planets. “I’m sorry it’s messy, but this is about astronomy growing up,” he says. “Everything is not black and white; we are not children anymore. There are all these shades of gray.”

Scientists in other disciplines grapple with similar organizational and nomenclature debates. Paleoanthropologists Donald Johanson and Richard Leakey were colleagues who in the 1970s argued bitterly over “missing link” fossils. Johanson argued that his Lucy fossil represented the common ancestor of *Homo sapiens* and ape-like primates. Leakey argued that his tool-making *Homo habilis* fossil was the common ancestor. Such disputes in biology continue. As each new animal gene is discovered and named by molecular biologists and geneticists, disagreements inevitably arise.

“When we first make discoveries, we frequently have an incomplete picture of what’s there,” says Frank Ruddle, a Yale University biologist. “I have discovered genes and given them what I think are adequate names. You have an attachment to them — your discovery and your naming of it. There is always a sense of regret when something is changed, but that is as it should be. You want terms that are accurate, descriptive, and easy to remember. Important names are those that provide deeper insights into what has been named.”

Nicholson calls the Pluto debate a “tempest in a teapot,” with little effect on the course of solar-system research. “No matter what we call it, people are not going to stop thinking about Pluto as a member of the Kuiper Belt,” says Nicholson. “All the current discussions about the origin of Pluto start on the premise that Pluto is a very big Kuiper Belt Object.” **A**

*Rex Graham is a senior editor at Astronomy.*



# The Supernova Guru

*Few scientists know more about how giant stars die  
than Stan Woosley.*

by Robert Irion

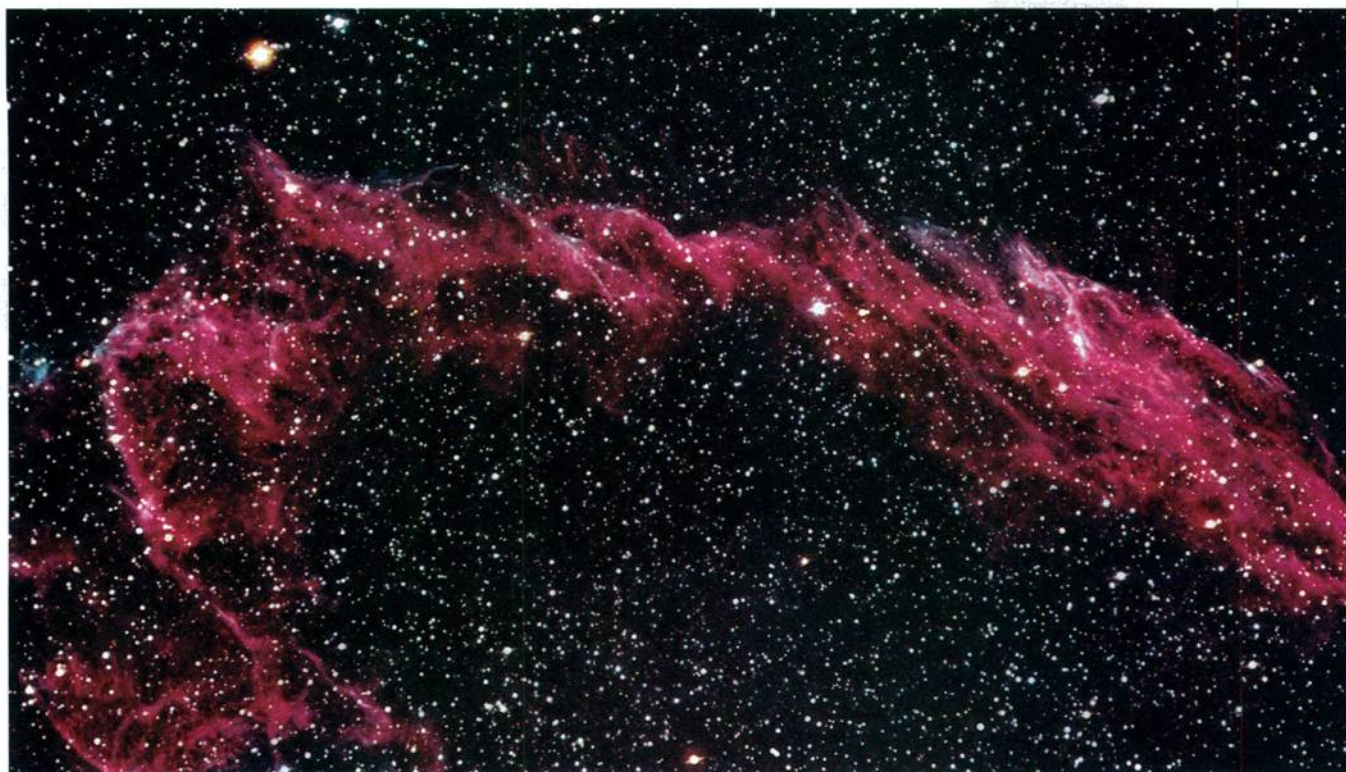
Once every second, somewhere in the universe, a star explodes. It blasts the cosmos with light and with ghostly particles that can penetrate 5 trillion miles of solid lead. Some of that light reaches Earth, giving astronomers a glimpse of a doomed star in a far-off galaxy. And some of those particles sail through the brain of theorist Stan Woosley, who understands that doomed star better than most.

Woosley is the master of big things that go boom. For three decades he has created mathematical models explaining the intricate physics of exploding stars known as supernovae. His work shows how these stellar suicides give rise to most of the atoms – and therefore elements – in the universe, including the copper in your phone line and the gold in your wedding band. And his newest research focuses on the biggest booms since the Big Bang: gamma-ray bursts. These cataclysms light up space with the most energetic radiation that exists. But what triggers them is still a mystery. Using new satellite technology to test his theories, Woosley suggests they may arise from the rarest, most colossal supernovae of all.









Bill and Sally Fletcher

"I've also wanted to understand where each and every element in the universe comes from, since we are made of those same elements."

"I've always been attracted to the most violent and energetic explosions one could find," says Woosley from his corner office at the University of California, Santa Cruz, amid redwood trees that echo his lean 6-foot frame. "The bigger the explosion the better, as long as it didn't hurt anybody. I've also wanted to understand where each and every element in the universe comes from. In part, that's studying our own origins, since we are made of those same elements."

### Getting Fired Up

One might expect such a career to rise from the ashes of a combustively enhanced youth. In this case, that's just partly true.

An only child born in 1944, Woosley memorized the periodic table of the elements by age 12 and loved to make things pop, fizzle, and glow. "When I was a kid you could still get good things at the drug store," he recalls. "I liked to make little bombs, but I wasn't a mad terror." He admits to a fire that destroyed a shed behind his house in Fort Worth, but he blames an electrical short in his makeshift chemistry lab. "My propane tank didn't help," he notes. "It truncated my chemistry for a while."

Young Woosley's real passion was space travel. He devoured science fiction, watched the Rocket Ranger Corps, and dreamed of walking on Mars. ("I'd still trade everything I have to go there," he says.) Sputnik's launch in 1957 and the space race stirred his imagination. After he enrolled at Rice University in 1962 to study physics, President Kennedy spoke to his class. "He said we were going to the moon and that there would be a space center near Houston," Woosley says. "That fired me up."

**The Veil Nebula, the remnant of a supernova explosion, harbors newly forged elements such as gold and iron.**

He joined a new space science program at Rice as a graduate student, but the first two years were discouragingly dull. His first adviser stuck him with an atomic-structure problem that required "hundreds of pages" of algebra. Woosley pondered fleeing to medical school, but two young professors, Don Clayton and David Arnett (now at the University of Arizona), got him involved in their research on nucleosynthesis: the creation of elements inside the nuclear furnaces of living and dying stars. "Not only did I learn that stars made elements, but they went bang besides," Woosley says. "It was a double whammy."

Clayton, who became Woosley's adviser, saw the first sparks of this fascination. "The idea that we could calculate the abundance of elements in the universe by understanding the explosions of stars was just poetic to Stan," says Clayton, now at Clemson University. "He has not relented for 30 years."

With his Texas comrades, Woosley spent four summers at Fred Hoyle's legendary astrophysics institute at the University of Cambridge. "It was the mecca for theoretical astrophysics," he says. Woosley's science bloomed as he worked alongside such luminaries as Hoyle, Margaret and Geoffrey Burbidge, Martin Rees, and the late David Schramm. He flowered socially as well: He toured England on a motorcycle, attracted women with his folksy guitar playing, and grew his brown curly hair to a peak radius.

In 1972, Woosley began working with the greatest influence on his career: nuclear physicist Willie Fowler of the California Institute of



Technology. They spent three years studying how reactions among lighter atoms spawn all the heavier elements. These reactions happen inside a star during its normal lifetime and in a fierce alchemical orgy when it explodes. Physicists still use the reaction rates that Fowler and Woosley calculated, although researchers are now using faster computers to update them. Fowler, a fatherly figure who died in 1995, won a share of the Nobel prize in 1982 for his work on the origins of the elements.

## Galactic Mixmaster

Woosley moved to UC Santa Cruz in 1975. The hilly campus was ideal for his long-legged stride. Also a bonus was the proximity to Lawrence Livermore National Laboratory, a two-hour drive to the north. There he entered a 20-year partnership with physicist Tom Weaver, who shared Woosley's desire to explore how huge stars evolve and die. The duo spent countless late nights devising a tight computer program, called "Kepler," that mimicked stars much larger than our sun. Their creation ran between weapons-designing programs on Livermore's powerful supercomputers.

The bloated gas balls simulated in Weaver and Woosley's program live fast and die young. In youth, the stars consist mostly of hydrogen. Under the intense pressure inside a giant star, hydrogen atoms crash into each other and combine into atoms of the next heaviest element, helium. The process, known as fusion, generates energy in the star. When the star fuses most of the hydrogen in its core, it begins fusing helium to forge carbon and oxygen. When these elements accumulate, they fuse into neon and magnesium, and so forth up the periodic table to iron. After millions of years of this process, the star's innards resemble an onion layered with the remnant shells of progressively heavier elements.

Iron marks the end of the line, however, because the heavy stable element consumes energy to fuse instead of creating energy. The core shuts down, and the outer layers rush inward. This triggers a titanic shock wave and a supernova explosion (see "Ka-Boom!" July 1997). The shock wave tears through the star, ripping apart atoms and freeing their neutrons. Nuclei swarming inside the blazing bubble capture the neutrons and become atoms of new elements. Here is where all heavy elements arise, including copper, silver, gold, and uranium. Over time, these elements drift into new dust clouds, stars, and planetary systems.

"Our galaxy is a big mixmaster," says Rob Hoffman, a former student of Woosley's now at Livermore. Based on the rate of supernovae (about one per galaxy per century) and estimates of how quickly interstellar material gets mixed, he says, "The atoms in each of our bodies almost certainly existed inside just one or several giant stars in our portion of the Milky Way."

Woosley and Weaver's program painstakingly describes these fires of creation. For instance,

their program reveals exactly how much cobalt will come out of a supernova from a red giant star with 25 times the mass of the sun. These elemental recipes, refined over the years, fill a binder the size of a big city's phone book.

"This is the best such work that has been done," says 92-year-old Nobel laureate and nuclear physicist Hans Bethe of Cornell University. "I consider Woosley the true successor to Willie Fowler."

It's satisfying to create such a complete set of theoretical predictions. However, astrophysicists crave observations to put their models to a stern test in the real universe. That happened for Woosley on February 23, 1987.

## Event of the Century

On that date, light from Supernova 1987A arrived at Earth 167,000 years after a star self-destructed in the Milky Way's galactic neighbor, the Large Magellanic Cloud. Woosley, who had just planned a ski trip, thought the first telegram about the explosion was a prank. "But then the phone began to ring," he says. "My next thought

## RESCUING RUSSIAN ASTRONOMY

Stan Woosley built his reputation on studying the biggest explosions in the universe, but he's known in other circles for saving the careers of colleagues whose livelihoods were disintegrating around them.

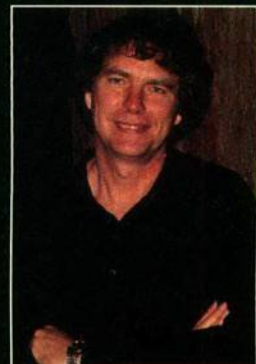
In the early 1990s, the Soviet Union's collapse left hundreds of talented astronomers in the lurch. Famed Russian astrophysicist Rashid Sunyaev pleaded for help from the American Astronomical Society council, on which Woosley sat. The salaries of young scientists were just \$10 a month, Sunyaev noted, so even grants of \$100 would keep them working. Woosley proposed that the AAS solicit money from its members, and he took charge.

During the next two years, Woosley catalyzed a program that raised about \$70,000. His team sent computer equipment, journal subscriptions, and grants of \$100 to \$500. "Russian banks weren't working, so we had to pass out money at meetings there," Woosley relates. "People at the bank must have thought I was a drug runner, because I was cashing \$10,000 checks and getting wads of \$20s."

The AAS program caught the attention of U.S. scientific groups, which mirrored it in other fields. Ultimately, industrialist George Soros gave \$100 million to help support all Russian sciences. Woosley chaired the astronomy part of that initiative.

Sunyaev verifies that the AAS donations kept young researchers in the field at a critical juncture. "This was an opportunity to change the future of the world for the better," Woosley says. "It may be the most important thing I ever did."

— RI



Terrell Wick



"If we had gamma-ray eyes and lived above the atmosphere, we'd see these glorious flashes as bright as Venus about once a day."

was, this is the event of the century, if not the millennium. I guess I'm not going skiing."

Indeed, SN 1987A ruled Woosley's life. For nearly two years, he worked with observational astronomers to examine the validity of his theories. He wrote a blizzard of academic papers, attended conferences, and revised his theories on what was happening inside the supernova. "I kept a running clock and was on supernova time, not solar time," he says.

The supernova itself dictated the relentless pace of that clock by spewing out one surprise after another. For example, the star that blew itself to smithereens was the wrong color. Astrophysicists thought that a type II supernova — the death of a hydrogen-rich star that runs out of nuclear fuel — happened at the end of a star's red giant phase. But charts revealed a giant blue star, called Sanduleak -69°202, at the spot of the explosion. Woosley, Weaver, and graduate student Phil Pinto, now at the University of Arizona, determined that such a star, more compact than a red giant and far hotter, could indeed blow up if it contained fewer heavy elements than expected. Within a few frantic days the team described that notion in the first paper written on SN 1987A.

Another surprise was how quickly the supernova shone in x rays and gamma rays. Those high-energy emissions appeared within about six months, at least three months earlier than most models forecast. Woosley's group proposed that turbulent blobs of hot material from deep within the star shot through the overlying gas faster than

anyone imagined. "This issue of mixing was one of the great lessons of 87A," Woosley says. "It led us to understand that the supernova was not just an expanding bunch of spherical shells."

But many aspects of the supernova's behavior matched Woosley's predictions. For instance, he and his colleagues forecast how the explosion's brightness would evolve. Their models held that the blast forged a huge supply (about one-tenth the mass of our sun) of radioactive nickel-56. That element quickly decays to cobalt-56. Over the next several months, the team predicted, the cobalt-56 would decay to iron, releasing energy and controlling the brightness of the fireball. Other theorists predicted a similar outcome, but Woosley's team hit closest to the mark.

A major, remaining riddle, he thinks, is what lurks at the supernova's heart. Woosley suspects the culprit is a neutron star — an ultradense cinder about 10 miles across (see "Pursuing the Most Extreme Stars," January 1999). A 10-second burst of elusive particles known as neutrinos detected on Earth convinced Woosley that a black hole didn't form. These particles transport almost all of the energy of a supernova explosion. Had a black hole formed, it would have swallowed the neutrinos within a second. Despite some tantalizing glimpses, however, astronomers haven't seen solid evidence of either a neutron star or a pulsar, a spinning neutron star that beams radiation into space.

## Collapsars and Black Holes

Woosley's command of supernovae serves him well on the topic du jour in astrophysics: gamma-ray bursts. For years, most astrophysicists (Woosley among them) believed these flares of

**The explosion of Supernova 1987A (upper left) confirmed the theories Woosley had modeled for years by computer.**



Noel Mulford



gamma rays came from objects such as highly magnetized neutron stars in or near our Milky Way Galaxy. Physicist Bohdan Paczynski of Princeton University argued against that tide, claiming they were colossal blasts coming from the fringes of the universe (see “Mastering the Mysterious,” June 1998). Now that satellite observations have proven Paczynski correct, theorists are scrambling to explain what triggers the bursts.

“They may be the greatest mysteries in astrophysics in the last quarter century,” Woosley says. “If we had gamma-ray eyes and lived above the atmosphere, we’d see these glorious flashes as bright as Venus about once a day, and then they’d never appear in the same place again. If you like explosions, they are the kings.”

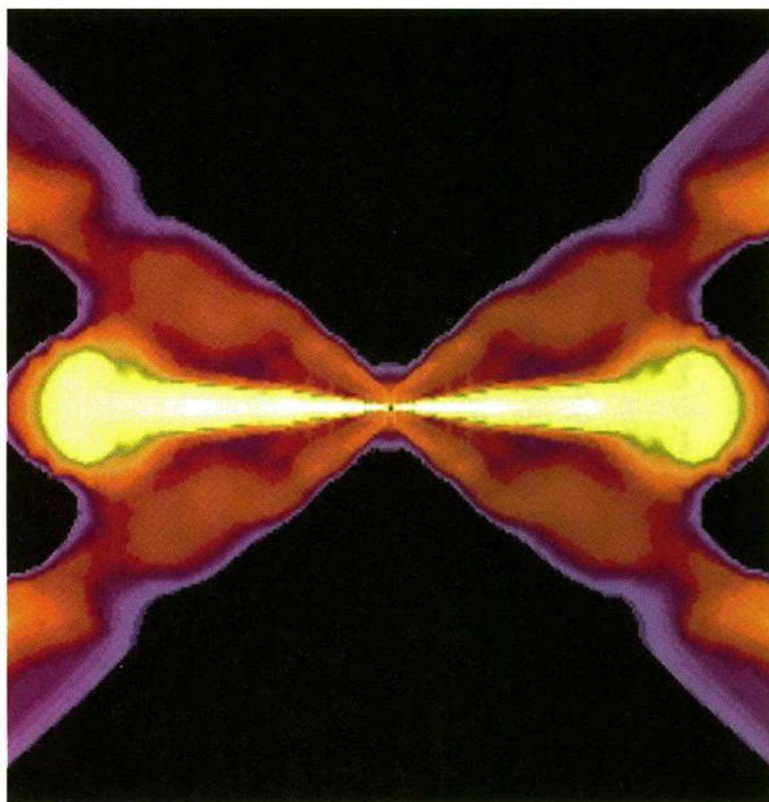
Woosley has concocted a half-dozen models for gamma-ray bursts over the years. His latest one — hatched with Santa Cruz graduate student Andrew MacFadyen and colleagues at Germany’s Max Planck Institute for Astrophysics — just might be right.

The researchers dub their solution the “collapsar” model, for “collapsing star.” They envision rare deaths of huge stars that create not neutron stars at their cores, but black holes. “The momentum of the infalling material is much greater for the biggest stars, and it’s hard to make an explosion,” Woosley says. “But I found it funny to think that one day you’d have a really big, bright star, and the next day no star, because it would all fall into a black hole and disappear. Could it really do that?” Perhaps not, his team maintains, provided that the dying star rotates quickly enough.

Woosley describes the exotic chain of events that might occur in 1 percent of all supernovae. The star’s massive core plummets into a black hole, which swallows gas from the slowly moving poles of the star. The rest of the star careens in a disk around the black hole at close to the speed of light. Within 20 seconds, the hole gulps the entire disk with mind-blowing ferocity. The inner part of the disk heats to 20 billion degrees and shoots stupendously energetic jets of particles out the top and bottom of the star, where the black hole has cleared narrow channels. Twisted magnetic field lines may help the jets drill into space, although computing magnetic fields in such a chaotic environment is nearly impossible, Woosley says.

The jets may collide with clumps of gas billions of miles from the star to create gamma rays. A more likely source of the bursts, Woosley thinks, is from particles within the jets crashing violently into one another. If this model bears up, he notes, it means that gamma-ray bursts are tightly focused. Astronomers would see only about 1 of every 100 that pop off in the universe — the ones that happen to point their bright beams at Earth.

The scenario gained credence last spring when European astronomers spotted a strange supernova, called 1998bw, in the same place where satellites had seen a gamma-ray burst a week before (see “Souped-Up Supernova,” November



Stan Woosley and Andrew MacFadyen

1998). The energy of the burst and the helium-rich spectrum of the supernova fit perfectly with the model’s predictions. “The timing of Supernova 1998bw was uncanny,” says MacFadyen. “It was exactly what I had been working on.”

Paczynski himself had suggested a similar engine, a “hypernova,” but says that Woosley’s theory is far more detailed. Observations of gamma-ray bursts show that they probably happen in star-forming regions of galaxies, Paczynski notes. That favors short-lived massive stars as the sources, because they don’t have time to wander from their cradles. A whirling pair of neutron stars, on the other hand — another popular model — would get a “considerable kick” when it forms. When the stars finally merge in a flash of radiation after a billion years or more, Paczynski says, they would be far out in intergalactic space.

Woosley thinks that collisions between neutron stars or neutron stars and black holes may explain an elusive class of bursts that lasts less than a second. In December, NASA will launch the High-Energy Transient Explorer 2, replacing a satellite that failed to separate from its rocket booster in 1996. HETE-2 will study gamma-ray bursts in the best detail yet, says Woosley, a mission collaborator. “The whole field will break wide open,” he predicts.

And when it does, expect Woosley to dive right in and miss a lot more ski trips. **A**

**According to Woosley’s and MacFadyen’s model, as jets of high-energy particles (yellow) drill out from the center of a collapsed star, they collide with surrounding low-density material, creating a gamma-ray burst in the direction of the jets.**

*Contributing editor Robert Irion works as freelance science journalist in Santa Cruz, California. He recently co-authored the forthcoming book, One Universe (Joseph-Henry Press).*



# Meteorites ON ICE

*Combing Antarctica for clues to the solar system.*

**Text by Beth Livermore and  
photos by Randy Korotev**

RALPH HARVEY IS AN UNLIKELY SPACE HERO. HE'S NEVER FLOWN INSIDE A rocket. The only aliens he fights are from boyhood fantasies, inspired by Major Matt Mason. But he has been closer to the moon than most astronauts and has contributed more mass to the study of planetary science than the Apollo and Viking missions combined. You see, Harvey is the director of the Antarctic Search for Meteorites (ANSMET) project. As such, he dons polar gear to search Antarctica's ice fields for invaders that have fallen from space.

Each winter, Harvey, a planetary geologist from Case Western Reserve University, and a team of about five adventuresome graduate students weather bone-numbing temperatures and ceaseless winds to harvest an average of 450 meteorites. As a result, ANSMET, funded by the National Science Foundation, has gathered more than 9,000 specimens in the past 20 years. Among the collection are charred bits of our primordial solar system, eight moon rocks from four different regions, and several chunks of Mars rock. Together they help explain how our universe evolved from a murky soup of dust and gas. Individually, they tell the secrets of mysterious extraterrestrial worlds.

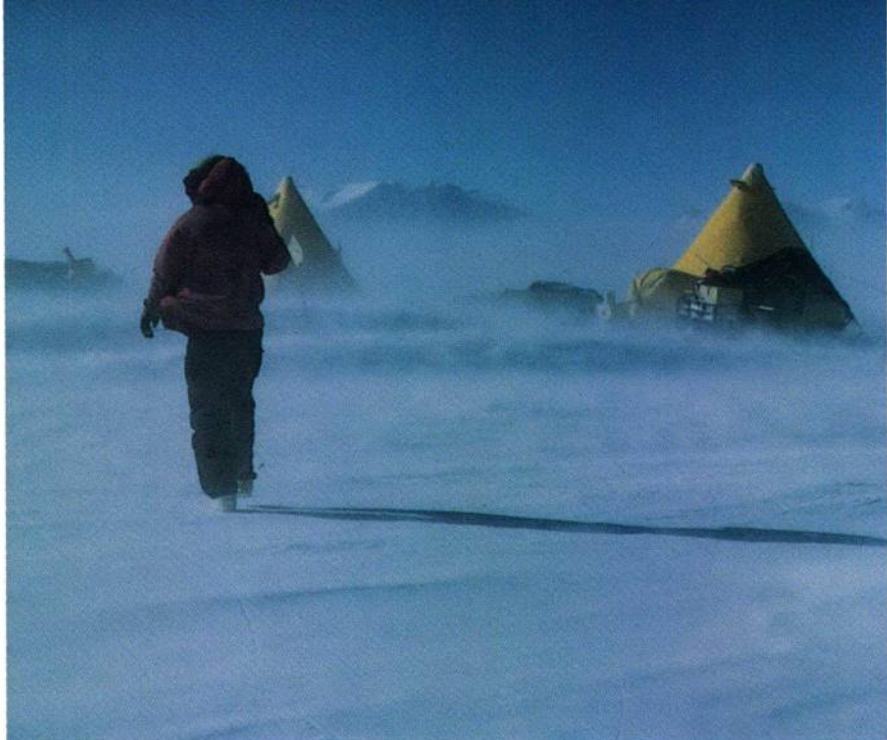
In fact, one Mars rock that looks like a burnt Idaho potato made international headlines when NASA researchers announced that it may provide the first







Previous page: Roberta Score, who found the martian rock that might hold signs of life, is lowered into a crevasse during survival training. Expedition leader Ralph Harvey coaches her. Mt. Erebus, the most southern active volcano, puffs in the background. Right: On most days in Antarctica, the snow blows persistently — at Scott tents and people.



evidence for life on the Red Planet. As a result, plans for a manned mission and even to “terraform” Mars for colonization have reemerged. President Clinton called for a “space summit” to discuss how best to investigate life on Mars. And high profile projects, such as Mars Pathfinder, which deployed an unmanned robot on Mars, and Global Surveyor, designed to orbit the cryptic sphere, have enjoyed unprecedented attention. Still, ANSMET remains substantially anonymous.

I learned about ANSMET accidentally by bumping into Ralph Harvey during a recent trip to Antarctica. He was passing through Shackleton Camp where I was working on his way home from the deep field. This temporary base camp, which consists of tents and Quonset huts, straddles a glacier plateau that stretches to the South Pole. Here “beakers,” or geologists and other scientists, eat dinner with the camp mechanics, construction workers, and



Kim McDonald



Far left: Monica Grady knits in her free time on a high-temperature day (22° F). Bags of snow near the tent will be melted for water. Center: Researchers measure a new find. Above: Geologists pose a large meteorite next to a camera for size comparison.

bush pilots who facilitate their missions. Harvey, who is 39 and built like a rugby player, can be easily mistaken for one of the latter. But, over a feast of lobster tails and fresh bread, he said “Had a great season. Got lots of rocks.”

“Really,” I said, “Meteorite hunters in Antarctica.” That was more surprising to me than the great food we were getting down there. Being an enthusiastic ANSMET spokesman, he explained.

Meteorites are bits of space debris that heat intensely as they enter Earth’s atmosphere and fall from the sky;

visible as “shooting stars,” or meteors, they have pelted our planet since creation — and will forever rain randomly on us. The lady in Peekskill, New York, who watched space debris land on her car two years ago, stands witness to that. So does the Cleveland man who recently traced the descent of a space rock with his videocamera at a football game. But most meteorites fall into the ocean and are lost. Those that reach land often blend with native rocks. Many desert specimens have either been collected and sold, are politically inaccessible, or are disintegrating.

So in 1969, the same year that Neil Armstrong left footprints in the lunar soil and Mariner 6 and 7 photographed



the surface of Mars, planetary scientists were ecstatic to learn that nine meteorites had been discovered by Japanese glaciologists in the Yamato Mountains. In 1976, ANSMET, led by Bill Cassidy of the University of Pittsburgh, made its first trip and returned with a 900-pound space rock — the largest yet. Now Antarctica, an uninhabited continent the size of Mexico and the United States combined, is considered by most scientists to be the world's best meteorite hunting ground.

To begin with, Antarctica's wind-scoured ice fields, which shimmer like crystal deserts, provide the perfect contrast to charred bits of blackened rubble. Then a natural process, whereby the ice sheets migrate from the continent's center toward the sea, creates collecting zones where mountains block the way. Stagnant ice mounds

wear away to reveal their riches. "If we're lucky, we can find up to 300 in an area the size of a football field," Harvey says. To collect them, team members line up their snowmobiles about 20 yards from one another and ride slowly, surveying their lanes for rocks. When a meteorite is spotted, everyone stops and gathers around to measure, tag, and chart its location with a portable Global Positioning Satellite unit. To protect against contamination, team members load meteorite samples into sterile bags using pristine tongs and tape leftover from the Apollo mission.

Still, while spotting them may be relatively easy, the missions themselves are not. To start, team members must board a cargo plane in Christchurch, New Zealand, and strap themselves in for a nine-hour flight to McMurdo base, during which frozen bologna

sandwiches and rare bursts of hot air are highlights. From there they fly several more hours to a vacant ice desert. There, with limited food, gear, and equipment, they may step into 20 knot winds and temperatures of  $-75^{\circ}\text{F}$  to set up a colony of Scott expedition tents — named after Robert Falcon Scott, the 20th-century explorer who died in one of them on his return from the Pole — where they will live for six weeks.

And this is just the beginning. Each day they commute to collecting sites through ice fields riddled with crevasses large enough to swallow entire trucks. Not so long ago, a Japanese rock hound fell into one and was lost forever. Once on site, they work from 8 A.M. to 6 P.M.,

**A normal meteorite search relies on snowmobile transport. Researchers usually ride in parallel patterns in search of dark stones.**







**A researcher prepares meteorites for collection.**

pausing only occasionally to fight off severe dehydration with a steamy mug of Tang, apply moisturizer to cracked lips and hands, and snack on peanuts to renew energy. "We were told to eat 5,000 to 7,000 calories a day to maintain our weight down there," says Randy Korotev of Washington University in St. Louis. "But between the work and the cold, I lost 18 pounds anyway."

Still worse is facing a whiteout. More than once the winds have been so fierce, the snow squalls so blinding, that the geologists have been confined to their 9x9-foot tents for more than two weeks. "If you don't like your tent mate it can be hell on Earth," Harvey says. "But if you can live in a book, it's not that bad." He passes time by working on a screenplay he calls "Elvis in Antarctica," scanning the shortwave for BBC news in Portuguese, and eating, eating, and eating some more. Besides he says, the rewards of working "on the ice" always outweigh the challenges.

Harvey remembers the day that he found his first moon rock. He was wandering in an area called Foggy Bottom when he stooped down and plucked what looked like an inside-out Oreo cookie from the ice. "I knew what it was immediately," he says. "And the whole thing came into focus for me. Here I was with fallen stars scattered at my feet. I was closer to the moon than many astronauts have ever been."

At the end of each season, the rocks are boxed and shipped, along with urine barrels and leftover supplies, to California. From here they are flown to

Johnson Space Center in Houston, where they are sorted and stored. Within six months they are profiled in a newsletter. Researchers, including Harvey, write for permission to examine the specimens. "So far ANSMET has doubled the number of distinct meteorites in the world's collection," says Marilyn Lindstrom, the meteorite curator at Johnson Space Center. More than 300 individual investigators representing 24 nations have conducted a wide spectrum of experiments on nearly 11,000 samples.

During a lecture to Oberlin College undergraduates, Harvey extolled the virtues of his Poor Man's Space Probe. "For the cost of a case of beer and about 600 pounds of food we can go out and pick up pieces of the moon, Mars, and asteroids that are delivered to us free of charge." In truth, the project costs about \$100,000 per year. But he compares this to the \$1 billion it takes to launch many single space missions. In addition, ANSMET provides a constant, reliable source of materials. This abundance also allows scientists to smash would-be museum relics into pieces and examine them like any other geological specimen. The result: new insight into the complex geology of asteroids and the unique conditions and substance of the solar nebula.

For example, chondrites, the most common group of meteorites, may reveal what conditions were like 4.6 billion years ago, as the sun and planets

were forming. Said to be the bricks and mortar of the cosmic world, they represent the solar nebula from which the sun and planets evolved. "We determine the composition and texture of our samples to infer the processes that formed the rock," says Allen Rubin, a geochemist at the University of California at Los Angeles. This, in turn, provides clues to the formation of the universe. Achondrites, another sort of space rock, describe a later chapter in solar history. These meteorites, which are 100 million years younger, are volcanic remnants from newborn planets.

But it is the truly exotic specimens that continue to electrify the scientific community. Among the favorites are the five achondrites that were blasted free from Mars during an asteroid collision. One rock, collected by Roberta Score in 1984, contains carbonate materials that some say reveal life. But Harvey has doubts about proving it.

He says that this theory is based "on six to seven pieces of evidence, which alone do not say anything." And Harvey's skepticism is shared by a growing number of distinguished colleagues. "There is fairly good evidence now that the PAHs (polycyclic aromatic hydrocarbons) are the result of terrestrial contamination," says Harry McSween, professor of geology at the University of Tennessee. "We think some of the 'fossils' are actually magnetite whiskers that formed in high temperatures, some are artifacts from preparation, and some are both."

Not surprisingly, Harvey and his team were not invited to the highly touted press conference that debuted ANSMET's now famous martian invader. Instead, he was sitting at his mom's kitchen table in Wisconsin when the big news was televised across America. But he does not seem to mind that he missed the spotlight. He says he is heartened by the public's interest in space science. In 1996 Harvey was told not to expect funding for the next three years. Following that first press conference on the martian rock, Harvey's proposal was approved. So this September as NASA takes its very public bows and reports pour in from Mars Global Surveyor, Harvey will once again zip up his parka and trudge the snows of Antarctica. **A**

*Beth Livermore, an Astronomy contributing editor and newly married, lives in New York.*



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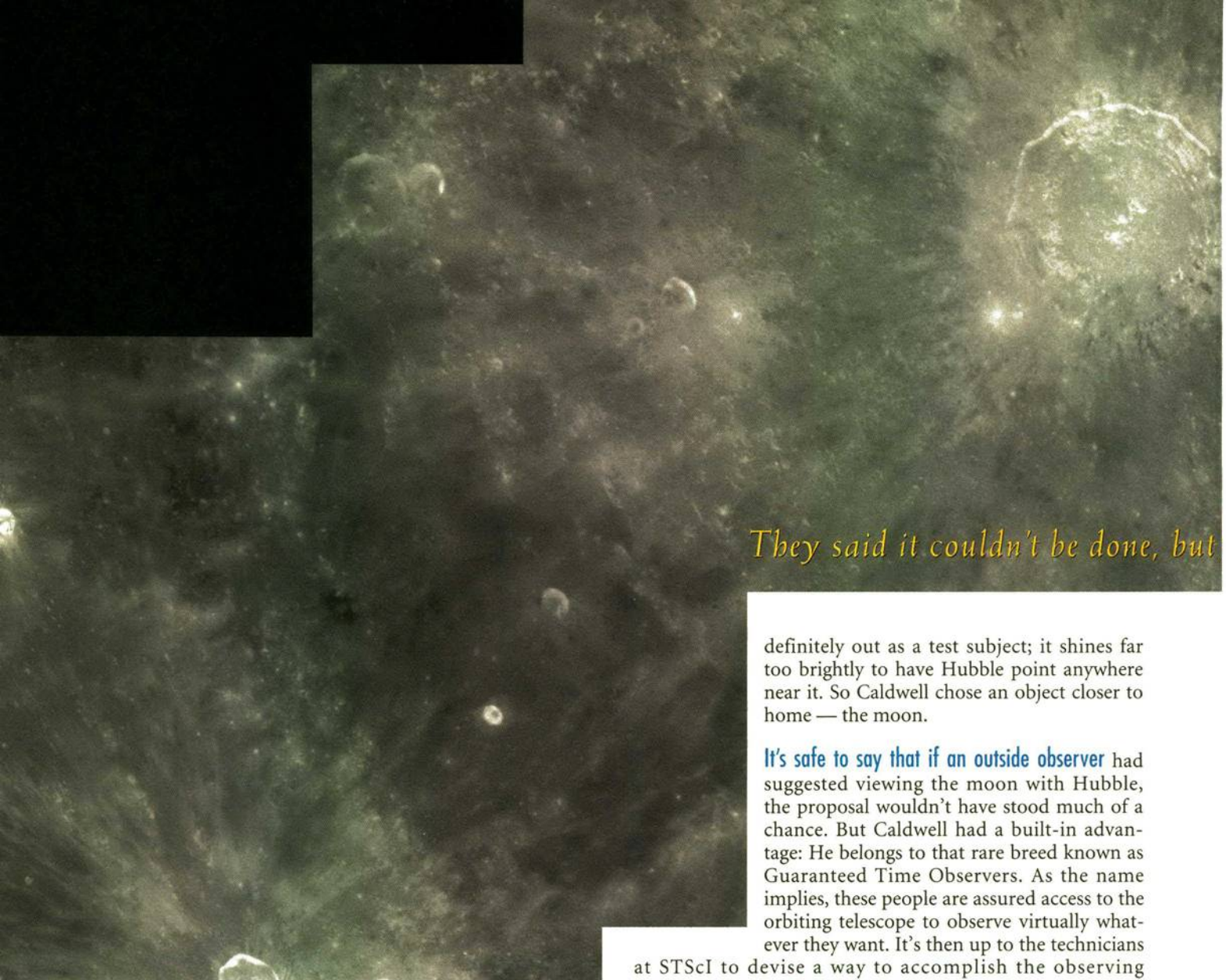
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*They said it couldn't be done, but*

definitely out as a test subject; it shines far too brightly to have Hubble point anywhere near it. So Caldwell chose an object closer to home — the moon.

**It's safe to say that if an outside observer** had suggested viewing the moon with Hubble, the proposal wouldn't have stood much of a chance. But Caldwell had a built-in advantage: He belongs to that rare breed known as Guaranteed Time Observers. As the name implies, these people are assured access to the orbiting telescope to observe virtually whatever they want. It's then up to the technicians

at STScI to devise a way to accomplish the observing program, if it's at all possible.

When Caldwell announced his plan in 1997, Tony Roman and Andy Lubenow of STScI got to work and figured out a way to track the moon as it moves across the sky. Hubble typically keeps an object centered in the field of view by using its Fine Guidance Sensors, which lock onto fixed guide stars and tell the telescope exactly where it is pointing. It's reasonably straightforward to track objects outside the solar system because Hubble's motion around Earth is small enough that they remain stationary relative to the stars.

It becomes trickier inside the solar system because planets, moons, asteroids, and comets are much closer and the spacecraft's orbital motion requires an onboard correction. This can be done when the telescope's Fine Guidance Sensors and gyros work in concert and the object's changing position is known precisely. Tracking the fast-moving moon, however, raised this challenge to a whole new level because the onboard correction would overflow Hubble's computer.

Caldwell chose as his target Mare Imbrium, the huge impact basin that spans some 780 miles (1,250 kilometers) and dominates the northwestern quadrant of the lunar nearside. When Storrs heard that the Space Telescope Imaging Spectrograph would be observing Imbrium, he suggested imaging the moon's surface with the Wide-Field/Planetary

**We're all familiar with the beautiful images** from the Hubble Space Telescope: Pictures of intricate spiral galaxies, luminous star clusters, colorful nebulae, and wonderfully detailed planets pour like rain from a springtime thunderstorm. Yet one object has always been conspicuous by its absence. Despite being a mere stone's throw away and offering a wealth of detail to boot, the moon remained off-limits, a gleaming beacon considered both too bright and moving too fast to make a good Hubble target.

Nevertheless, where there's a will, there's usually a way. "Hubble is a wonderful, versatile instrument," says Alex Storrs of the Space Telescope Science Institute (STScI) in Baltimore, Maryland, and leader of the team that photographed the moon. "Its perceived limitations have more to do with a lack of funding and ground support than with anything inherent to the telescope."

John Caldwell of York University in Toronto, Canada, got the ball rolling. He planned to use Hubble for taking spectra of Saturn's moon Titan as well as the Galilean satellites of Jupiter. To better understand the spectra of sunlight reflected off these objects, however, he needed to test Hubble's capabilities on another target. The sun was



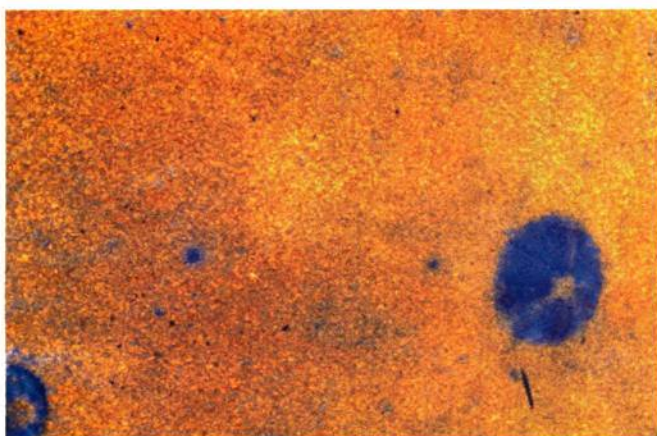
# Hubble Shoots the Moon

*astronomers have managed their first ever view of the moon through Hubble.*

Camera 2 at the same time. Observing with filters that let only a small fraction of the moon's light pass through and keeping exposure times to less than a second, the team managed to diminish the moon's glare enough to get the pictures shown here.

The team targeted an area near the southern margin of Mare Imbrium that stretches from the prominent crater Copernicus west to the smaller crater Kepler. Eight images were taken on November 6, 1998, just two days past full phase, and combined to produce the mosaic shown on the opposite page. (Hubble would have to take 130 images to create a mosaic of the entire lunar disk.) The image shows little topographic relief because the sun lay almost directly overhead at the time, so shadows were just about nonexistent. Still, the detail is extraordinary. Theoretically, Hubble can deliver images with a resolution of 280 feet (85 meters) — slightly better than that of the Clementine spacecraft, which orbited the moon in 1994. In practice, however, the ground controllers weren't able to correct precisely for the moon's changing position, so the resolution wasn't quite that sharp.

**The giant crater Copernicus** spans 58 miles (93 km) and shows a bright rim and deep, terraced walls. This relatively young



crater formed when an asteroid more than a mile wide slammed into the moon some 800 million years ago. A group of central peaks rises nearly 4,000 feet (1,200 m) above the crater's flat floor, which digs down 12,300 feet (3,760 m) below the level of the surrounding terrain. Another relatively recent impact created the 20-mile-wide (32 km) crater Kepler, seen at the very bottom of the mosaic. The impacts that created Copernicus and Kepler blasted out tons of material, forming a pair of bright ray systems that adds to the craters' prominence around the time of full moon.

The imaging team constructed a mineralogical map (below, left) of part of this region from exposures taken through three different filters. The map is centered near the crater Milichius, which lies about 185 miles (300 km) west of Copernicus and 155 miles (250 km) east-northeast of Kepler. (You can find the crater some 45 percent of the way along, and slightly above, a line from Kepler to Copernicus.) Milichius is much smaller than Copernicus and Kepler, only 8 miles (13 km) across, and significantly older. The bright ray systems of the younger craters interact here.

The yellow color in the mineralogical map represents aged ejecta from the crater as well as the surrounding mare material. The bright blue of the crater itself and its neighbor to the west, Milichius A, depicts fresher deposits exposed when landslides carried material down the walls of the craters. The centers of both craters remain yellow because the fresher material could not slide that far.

**Now that Storrs and his colleagues** have shown that Hubble can image the moon, it opens a whole new arena for lunar scientists. Several proposals have been made to STScI for future observations, including one to study the boundaries between highland regions and maria to help interpret many of the Clementine images. Perhaps even more intriguing is a proposal to view the landing site of Apollo 11: At the right lunar phase, the shadow of the Lunar Descent Module should be visible on the plains of Mare Tranquillitatis, the tallest structure on that flat expanse of lunar terrain first trod by humans 30 years ago. —Richard Talcott

A





**Three lunar occultations, a partial lunar eclipse, and several bright planets highlight July's sultry night sky. by Martin Ratcliffe and Alister Ling**

Warm summer evenings are the perfect time to learn or reacquaint yourself with the stars of summer. Open the circular Star Dome map on pages 65–66 to find the secrets held by the summer night sky. Take the map outside with a very dim or preferably red flashlight. To see a particular view of the sky, rotate the map so that the direction indicated at the bottom of the page is also the direction you are facing. The center of the map represents the overhead view.

Begin the journey with the bright gems that are obvious at first glance. Face

south and the rich Milky Way will be easily visible to country residents. City and town dwellers will have to be satisfied with a view of the brighter stars that merely hint at the splendor seen in a dark country sky. Even so, a city view is ideal for the beginner who is learning his or her way around the night sky.

Late in the evening, check overhead for the brightest of the summer stars, Vega. It lies 24 light-years away and is part of the constellation Lyra the Harp. Near Vega is the famous double-double, Epsilon ( $\epsilon$ ) Lyrae. These

two 5th-magnitude stars lie just over 3' apart and can be split in binoculars. Each of these stars is itself a double, but you need a telescope to split them into their component stars.

To Vega's northeast you'll find Deneb in Cygnus the Swan. Deneb marks the tail of an elegant swan that flies along the Milky Way. In fact, Deneb and Cygnus can help city residents locate the Milky Way. The swan's wings are spread perpendicular to the faint band, while her long graceful neck runs parallel to it.

Those who pointed their telescopes toward Epsilon

Lyrae should also take a look at the swan's head, the incomparable double star Albireo. This twosome pairs a 3rd-magnitude yellow star with a 5th-magnitude blue star. It offers observers one of the finest color contrasts in the sky.

High in the southeast, about halfway up from the horizon, is Altair in Aquila the Eagle. *Star Trek* fans may notice Aquila's resemblance to the communication badges crew members wear on their uniforms. To the

**The moon, Venus, Mars, and Jupiter as seen from the Superstition Mountains in Arizona.**



Frank Zullo



- 1 The moon passes  $0.4^{\circ}$  north of Uranus, 11 P.M. EDT
- 6 Last quarter moon is at 7:57 A.M. EDT  
Earth is at aphelion (94.5 million miles from the sun), 6 P.M. EDT
- 7 The moon passes  $4^{\circ}$  south of Jupiter, 11 A.M. EDT
- 8 The moon passes  $3^{\circ}$  south of Saturn, 11 A.M. EDT
- 10 The moon passes  $0.8^{\circ}$  north of Aldebaran, 5 A.M. EDT
- 11 The moon is at perigee (224,798 miles from Earth), 2:09 A.M. EDT
- 12 New moon is at 10:24 P.M. EDT
- 13 Venus passes  $1.5^{\circ}$  south of Regulus, 3 A.M. EDT
- 14 The moon passes  $3^{\circ}$  north of Mercury, 5 A.M. EDT  
Venus is at greatest brilliancy (magnitude  $-4.5$ ),  
3 P.M. EDT (page 68)
- 15 The moon passes  $1.1^{\circ}$  north of Regulus, 5 P.M. EDT  
The moon passes  $3^{\circ}$  north of Venus, 7 P.M. EDT
- 20 First quarter moon is at 5:00 A.M. EDT  
The moon passes  $7^{\circ}$  north of Mars, 6 P.M. EDT
- 23 The moon is at apogee (251,609 miles from Earth), 1:45 A.M. EDT
- 24 Asteroid Ceres is in conjunction with the sun, 1 A.M. EDT
- 26 Neptune is at opposition, 6 A.M. EDT  
Mercury is in inferior conjunction, noon EDT
- 28 The moon passes  $0.6^{\circ}$  north of Neptune, 4 A.M. EDT  
Full moon is at 7:25 A.M. EDT, partial lunar eclipse (page 68)
- 29 Southern Delta Aquarid meteor shower peaks  
The moon passes  $0.5^{\circ}$  north of Uranus, 3 A.M. EDT

| Sun. | Mon. | Tue. | Wed. | Thu. | Fri. | Sat. |
|------|------|------|------|------|------|------|
|      |      |      |      | 1    | 2    | 3    |
| 4    | 5    | 6    | 7    | 8    | 9    | 10   |
| 11   | 12   | 13   | 14   | 15   | 16   | 17   |
| 18   | 19   | 20   | 21   | 22   | 23   | 24   |
| 25   | 26   | 27   | 28   | 29   | 30   | 31   |

East

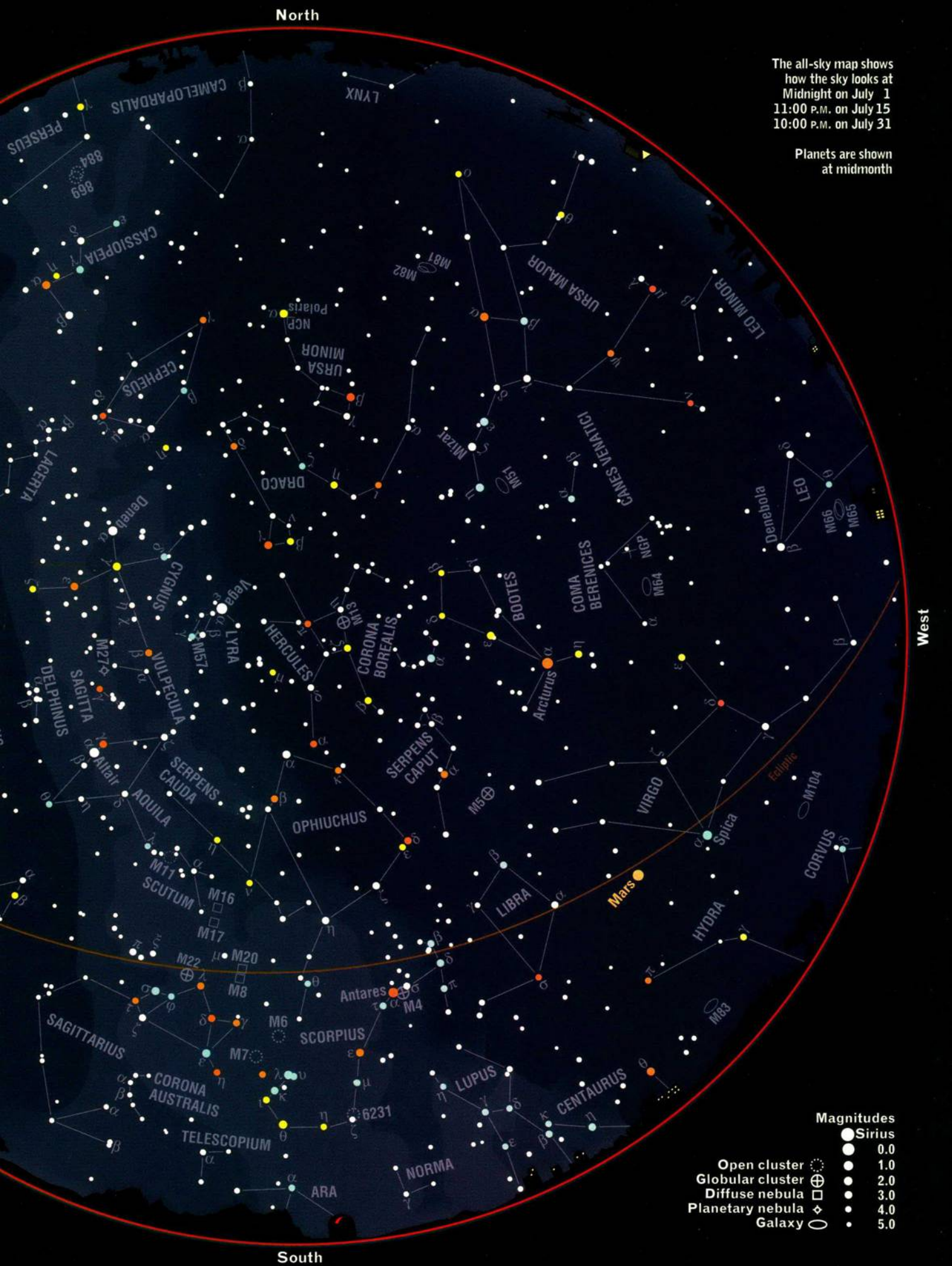
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



North

The all-sky map shows  
how the sky looks at  
Midnight on July 1  
11:00 P.M. on July 15  
10:00 P.M. on July 31

Planets are shown  
at midmonth



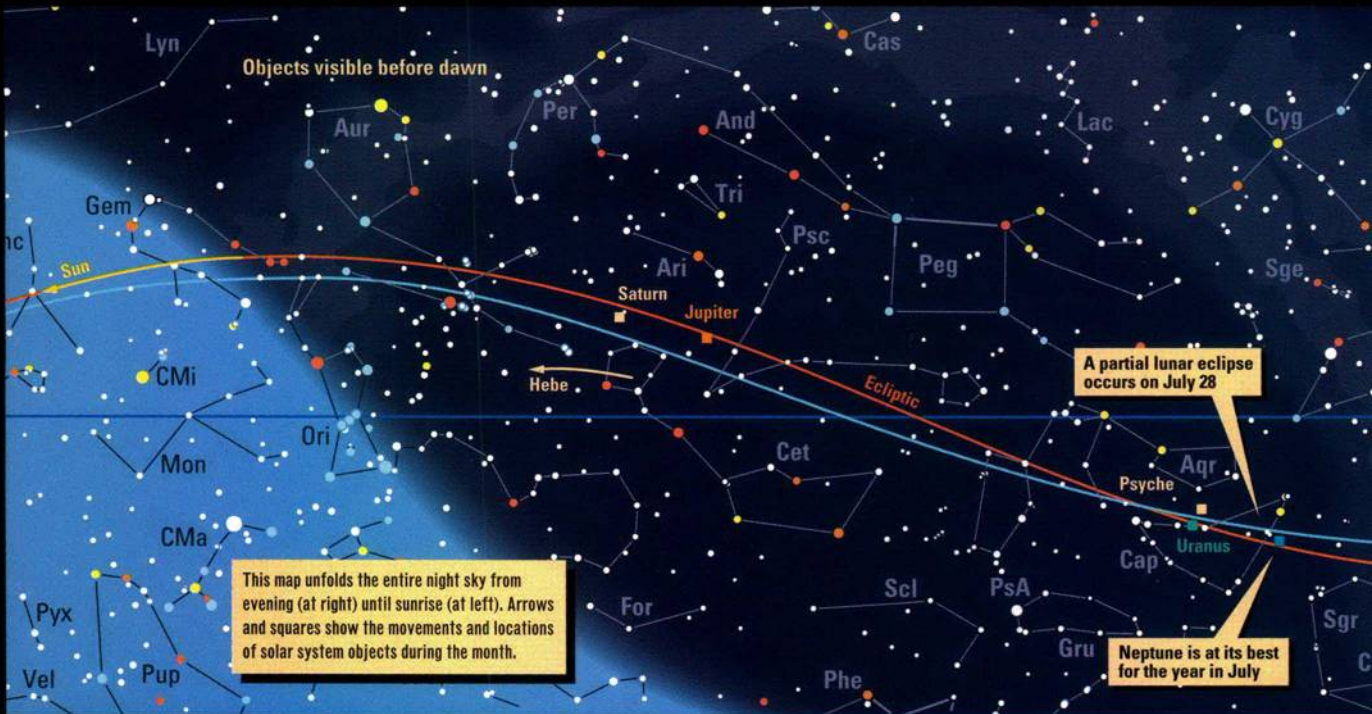
West

South

- Magnitudes
- Sirius
  - 0.0
  - 1.0
  - 2.0
  - 3.0
  - 4.0
  - 5.0
  - Open cluster
  - ⊕ Globular cluster
  - Diffuse nebula
  - ◇ Planetary nebula
  - Galaxy



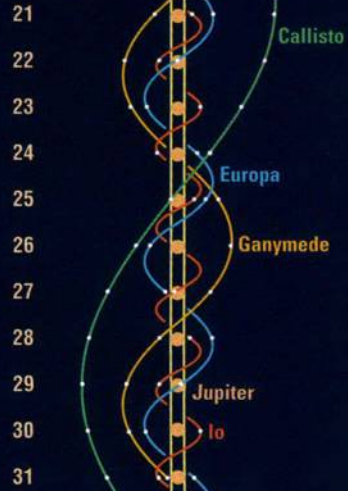
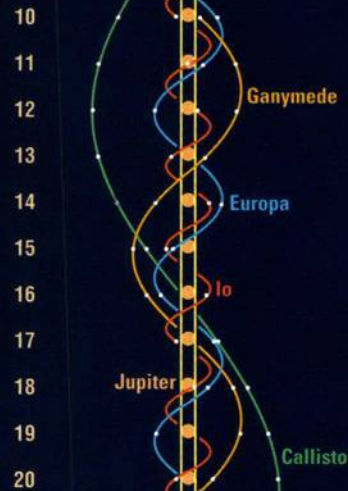
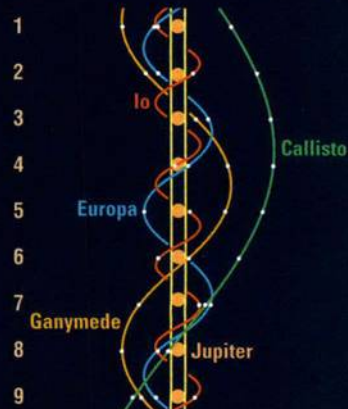
# THE PATH OF THE PLANETS



| PLANETS                  | W | E | MERCURY | MERCURY | VENUS   | VENUS    | MARS     |
|--------------------------|---|---|---------|---------|---------|----------|----------|
| Date                     |   |   | July 1  | July 15 | July 1  | July 31  | July 1   |
| Magnitude                |   |   | 0.7     | 2.2     | -4.4    | -4.4     | -0.4     |
| Angular Size             |   |   | 8.5"    | 10.8"   | 30.3"   | 48.2"    | 11.5"    |
| Illumination             |   |   | 37%     | 12%     | 37%     | 12%      | 89%      |
| Distance (AU) from Earth |   |   | 0.796   | 0.620   | 0.552   | 0.346    | 0.81     |
| Distance (AU) from Sun   |   |   | 0.453   | 0.464   | 0.725   | 0.728    | 1.50     |
| Right Ascension (2000.0) |   |   | 8h26.0m | 8h43.4m | 9h40.1m | 10h21.4m | 13h45.0m |
| Declination (2000.0)     |   |   | 19°07'  | 14°38'  | 14°45'  | 5°32'    | -12°00'  |

## JUPITER'S MOONS

Dots display positions of Galilean satellites at 4 A.M. EDT on date shown. South is at top to match the view in a telescope.

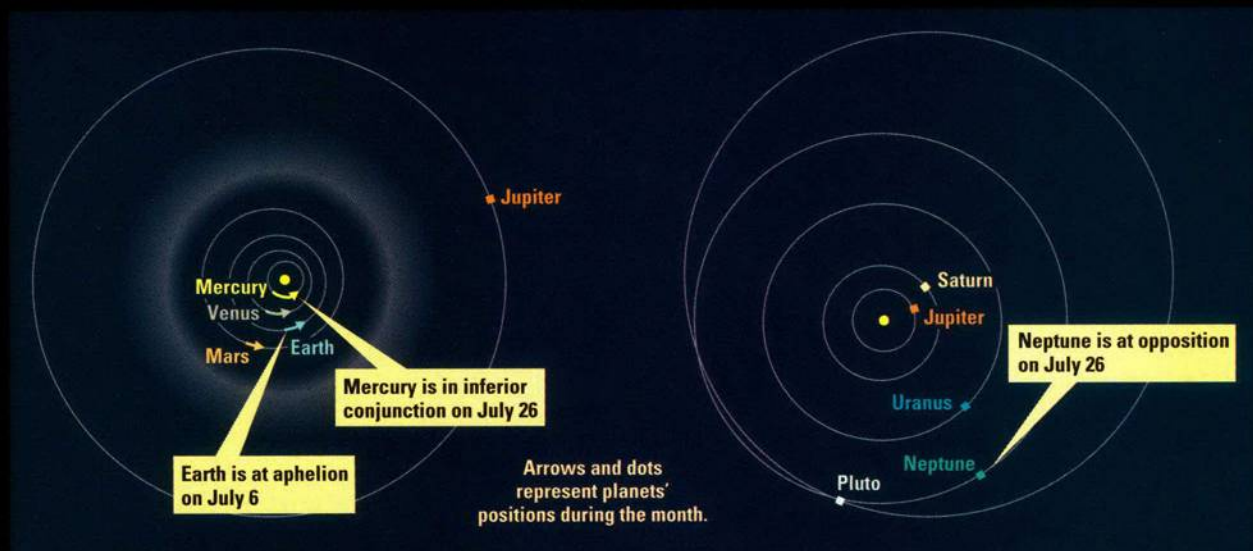






|    | MARS     | JUPITER | SATURN  | URANUS   | NEPTUNE  | PLUTO    |
|----|----------|---------|---------|----------|----------|----------|
|    | July 31  | July 15 | July 15 | July 15  | July 15  | July 15  |
|    | 0.0      | -2.4    | 0.3     | 5.7      | 7.8      | 13.7     |
|    | 9.4"     | 39.2"   | 17.4"   | 3.7"     | 2.3"     | 0.1"     |
|    | 86%      | 99%     | 100%    | 100%     | 100%     | 100%     |
|    | 0.999    | 5.030   | 9.576   | 18.971   | 29.129   | 29.451   |
|    | 1.467    | 4.951   | 9.222   | 19.907   | 30.127   | 30.175   |
| m  | 14h31.8m | 2h02.4m | 2h54.5m | 21h13.7m | 20h22.1m | 16h32.7m |
| 2' | -16°34'  | 11°06'  | 14°15'  | -16°48'  | -19°09'  | -10°06'  |

## THE PLANETS IN THEIR ORBITS







## FIRST VIEWS: Big and Bright Globular Cluster M4

**Y**ou can blame Antares or thank Antares. If it weren't for the fact that this bright-red star rests nearly in front of the dense and distant swarm of stars dubbed M4 (NGC 6121), you'd be able to spot the cluster unaided in a dark sky. On the other hand, swing binoculars onto Antares to find M4's small glow just two to three moonwidths ( $1.3^\circ$ ) to the right. The star makes finding the cluster a snap.

M4 is the seventh brightest globular cluster in the sky and a delight in the eyepiece. A 3-inch telescope will start to pull in the brightest of M4's supergiants that glow at magnitude 10.8. A 5 incher will handily pull in the vast numbers of horizontal branch giants, transforming the fuzzball into an assemblage of jewels. If you know somebody with a really big scope, ask him or her to point it toward M4. A high-powered view in a large instrument will knock your socks off. When it comes to bright giant stars, M4 ranks second only to the far southern globular NGC 6397.

One of the nearest globular clusters to the solar system, M4 rests at the southern fringe of the Rho ( $\rho$ ) Ophiuchi nebulosity. The photo at right shows the bright star at the top and center of the frame. M4 and Antares can be found at the bottom. The globular cluster is the lower right object, and the star sits directly to the east (lower left).



Gerald Rhemann and Franz Kerschke

Also in the vicinity is NGC 6144. This diminutive globular seems to hover between its larger cousin, M4, and Antares. Look for NGC 6144's small globular form above and to the right (northwest) of Antares at roughly 1–2 o'clock.

At 9th magnitude, NGC 6144 is a far fainter globular than 7.4-magnitude M4. You may not see more than a faint, misty patch near the glow of Antares. Don't let that brilliant star slide into the field of view — it will ruin your dark adaptation.

Another bright object shown in the photo is Sigma ( $\sigma$ ) Scorpii. Look for the bright blue giant star above and to the right (northwest) of M4.



Lee C. Coombs

ancient Greeks, Aquila was known as the Thunderbird who returned the lightning bolts Zeus threw at Earth.

Vega, Deneb, and Altair mark the three stars of the Summer Triangle. This asterism represents an easy branching point to locating other stars. It takes time to learn the fainter groups of stars. Start with what is

easiest and you'll soon find your way around the summer sky.

Flip the map over so that "north" is at the bottom of the page. The Big Dipper is in the northwest, its handle arching upwards. Follow that arc to the star Arcturus, high in the west. Arcturus is an orange-colored star in Boötes the

Herdsmen. It shines like a solitary beacon among the dimmer stars of that region. Continue the imaginary arc down to the southwest. There you'll find the bright star Spica in the constellation Virgo. Another bright interloper can also be found in this neighborhood, the Red Planet, **Mars**.

When looking at Mars, you might think you've found the twin of Arcturus. Mars and Arcturus appear about the same brilliance this month, though Mars will shift its position nightly. July begins with the planet roughly  $5^\circ$  east of Spica. On July 20, the 30th anniversary of the first moon landing, a first quarter moon forms a



nice triangle with Mars and Spica. By July 31, Mars has moved into Libra and lies 4° west of the beautiful double star, Zubenelgenubi (Alpha [α] Librae). Over the course of the month, Mars dims from magnitude -0.4 to 0. Viewing details on the planet's surface becomes a challenge as its apparent diameter shrinks to under 10".

If you catch Spica and Mars soon after dusk, say around 10:30 P.M. local time, you won't be able to miss the brilliance of **Venus** low in the west. It outshines everything in the sky except the moon. The brightest Venus can become is magnitude -4.5, which is achieved on July 17. During the week leading up to this date, Venus lingers close to Regulus, the first magnitude star leading Leo the Lion toward the western horizon. On July 11, Venus lies a mere 1.2° away from the Lion's heart. It shines a staggering two hundred times brighter than Regulus.

A view of great beauty awaits observers late on the summer evening of July 15. Look for a fine, delicate crescent moon low in the west, standing 2° away from Venus. In the deepening twilight, watch for earthshine on the dark side of the moon. As the sky darkens, the moon's ashen limb will become quite prominent.

A telescopic view of Venus shows a phase similar to that of the moon. The planet's crescent phase undergoes rapid changes this month — shrinking from 37-percent illumination to a mere 12 percent (similar to the moon's July 15 appearance). At the same time, its apparent size grows noticeably. Venus reaches 48" on July 31. (See "Venus

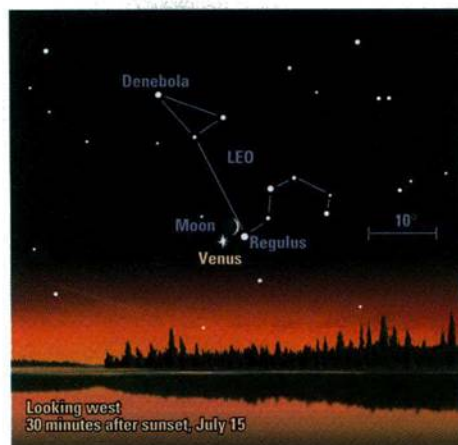
## Going Out in a Blaze

**V**enus has dominated the evening sky, but that soon comes to an end. The brilliant planet will soon swing in front of the sun to reemerge in September as the "Morning Star."

If you want to see rapid change in the planet's appearance, now is the time. As Venus catches up to Earth in their orbital race, she grows in apparent size, from 30" on July 1 to 40" on July 20. During this time, her phase slims from a 37-percent-illuminated crescent (a bit less than a half-moon width) to a delicate 20-percent crescent.

A similarly shaped moon joins Venus on July 15. Also look for Regulus, just to the moon's lower right — though you may need binoculars to find the star that marks the Lion's heart. By mid-month, Venus has reached greatest brilliancy, a radiant magnitude -4.5.

To find Venus during the daytime with your naked eye, follow this simple trick. On July 1, walk outside and hide the sun



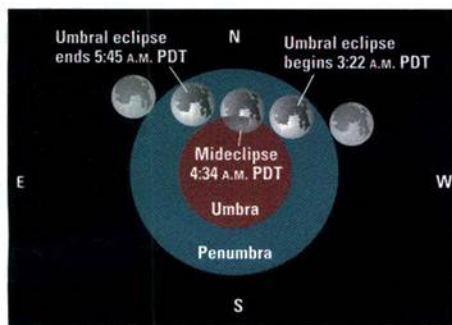
behind a streetlight or the top of a flag pole, taking note of where you place your feet. Return exactly 3 hours later and Venus will be behind the pole, in the same spot the sun was. On July 8, Venus will be two hours and 50 minutes behind the sun. On July 15, it will be two hours and 33 minutes later.

All illustrations Astronomy: Elisabeth Rowan

## Partial Lunar Eclipse

**T**he last decent lunar eclipse for North America was just over two years ago. If the moon orbited right along the ecliptic (the sun's path through the sky) we'd see an eclipse every month. The orbit's slight tilt (6.7°) makes these events less frequent.

The moon enters the dark umbra of Earth's shadow on July 28 at 6:22 A.M. EDT. Observers east of a line from Detroit to South Carolina will be unable to see the event. Only those on the west coast and in Hawaii can watch the entire umbral event starting at 3:22 A.M. PDT.



Christian Vladrich

Binoculars or a telescope will give you a ringside seat for the event. Watch the downward curved shadow gradually swallow up the bright lines of Tycho's rays. In a telescope, you can actually see the shadow cross the crater floor second by second.

If you miss this one, you may be in luck. The next total eclipse for North America is only six months away. Alas, it occurs in the dead of winter (January 20-21), but the moon will be high in the sky.



## The God of War Retreats

**M**ars declared war on Spica but is now retreating. In April, the Red Planet was at magnitude  $-1.6$ , slightly brighter than the brightest star, Sirius. By the end of July, it dims past magnitude 0. Spica's blue, 1.0-magnitude light will then dominate the southwestern sky as Mars retreats eastward.

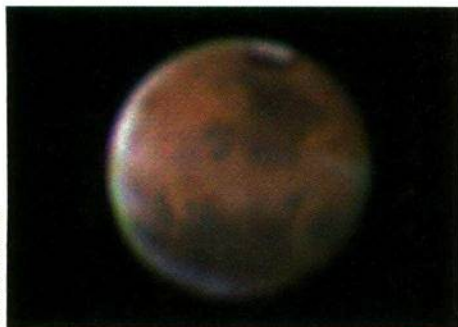
Though past its glory, don't give up on Mars. Start observing as soon as the sun sets. There is plenty of detail left to see on the planet's disk, still slightly more than  $10''$  across.

A perfect opportunity is offered later this month to achieve a personal best.



During the late afternoon hours of July 20, a first quarter moon sits  $6^\circ$  (about one binocular field) above Mars. If you picture the terminator line on the moon as a line running from 12 o'clock to 6 o'clock, Mars can be found at 7 o'clock. First look for it in binoculars, then see if you can pick it out with your naked eye.

Mars sits right in the middle of the sky's polarization band, where the sky is darkest. You can increase the contrast further by wearing polarizing sunglasses and tilting your head to darken the sky. Let us know how you fared.



Maurizio Di Sciuolo

## Kalliope Crawls through the Scorpion

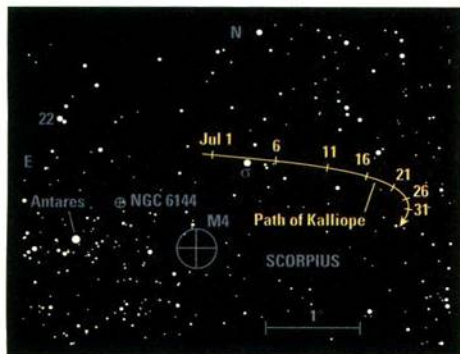
**I**t's rock hunting time again. Our target: asteroid 22 Kalliope. This 120-mile-wide (190 km) cratered rock is cruising the middle ground of the solar system between the orbits of Mars and Jupiter.

In contrast to many other asteroid observations, this target will not be a challenge. The first step is to locate the heart of the Scorpion, the star Antares.

Adjust your scope  $2^\circ$  to the right onto 3rd-magnitude Sigma ( $\sigma$ ) Scorpii and you're there.

For the first week of July, Kalliope is less than a moon's width ( $30'$ ) from Sigma. It slices a mere  $2'$  from it on July 4. Chances are you'll lose the 1.3-magnitude asteroid in the glare of the star that night, but you might try finding it with high power. For the rest of the month, use the field stars on the chart as reference points to spot this interloper.

Why, you may be wondering, is such a low-numbered asteroid so faint? The early asteroid discoveries were, for the most part, brighter objects. Kalliope has a fairly elliptical orbit. On its current pass, the asteroid is near its farthest point from the sun. This distance is practically an entire astronomical unit farther than when Kalliope is at its closest point to the sun.



Rising," February 1999, for further details.)

**Mercury** remains briefly visible in the evening sky before heading toward a July 26 inferior conjunction with the sun. Look for it low in the west 45 minutes after sunset during the first few days of July. It fades quickly, below first magnitude, by July 5.

After Mercury and Venus have set, focus on the southern region of the sky. Here, within the constellations Scorpius and Sagittarius, the Milky Way is at its richest. The brightest star in the region is magnitude 1.0 Antares, part of Scorpius the Scorpion. The star's name means "rival of Mars."

If the Milky Way is overshadowed by light pollution, use a pair of binoculars to increase your observing prowess. Scan the region to the east of Antares. Open star clusters and nebulae abound there.

Lying above the tail of the Scorpion are M6 (NGC 6405) and M7 (NGC 6475), a pair of wonderful open clusters that are easily seen in binoculars. A couple degrees east of the 3rd-magnitude star Lambda ( $\lambda$ ) Sagittarii is M22 (NGC 6656), the brightest globular cluster in the Archer.

Above Sagittarius's teapot shape is the Lagoon Nebula (M8) — a striking object in both binoculars and a telescope. Only  $1^\circ$  north of the Lagoon lies the Trifid Nebula (M20), laced with dark tendrils.

North and slightly east of M20 are two more fairly bright and famous nebulae. The Omega Nebula (M17) is the southernmost object. Just to its north is the Eagle Nebula (M16). This mélange of gas and dust was



made famous by Hubble Space Telescope images. As is the case with nebulae, the telescopic view will never match the photographic one. Yet seeing these objects personally and recognizing their true nature and scale is a satisfying experience.

Closer to home, two planets attract special attention. Rising in the southeast among the stars of Capricornus the Sea Goat are **Neptune** and **Uranus**. Both planets will be occulted this month by an intervening moon. The events take place just one day apart, on July 28 and July 29. The first event occurs roughly one hour before the moon enters Earth's penumbral shadow — the beginning of a partial lunar eclipse. The disappearance of dim 7.8-magnitude Neptune takes place near local midnight on the west coast and shortly after 4 A.M. local time on the east coast. Its faintness will make seeing the occultation a challenge for small scopes. The reappearance of Neptune occurs after the moon has entered Earth's penumbral shadow for the eastern half of the United States. Check the International Occultation Timing Association's (IOTA) website for local times of events (<http://lunar-occultations.com/iota/iotandx.htm>).

During the early hours of July 29, the moon occults Uranus almost exactly 12 hours after the Neptune event. Uranus shines at magnitude 5.7, making it an easier object to view close to the nearly full moon. Using high magnification helps to shift most of the moon's brilliance outside the field of view, making Uranus easier to observe.

## Jupiter Takes Aim at Saturn

The morning sky belongs to the inner gas giants. With no bright stars to confuse observers, the colors of dawn highlight the pair in the early morning sky. Jupiter is brighter at magnitude -2.3 despite Saturn's more open rings, which reflect additional sunlight.

A further addition to the view arrives July 7. The thinning crescent moon comes within a binocular field of Jupiter. The next morning it sits a bit closer to the right of Saturn. The delicate, almost straight lineup on July 9 is worth waking up early to see.

As the months tick by, Jupiter will close in on magnitude 0.3 Saturn. These giant planets begin the month 14° (2



binoculars fields) apart. By next April, they lie less than 10° apart. I can hardly wait until 2001, when they tango.

## The Return of Comet Tempel 2

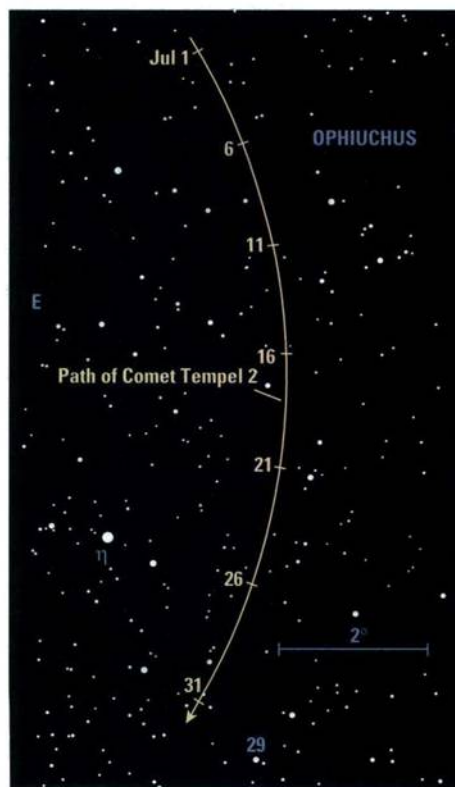
Compared to recent years, it feels as though we're in a drought of bright comets. Most observers yearn to watch these fascinating intruders at every opportunity. This month, comet Tempel 2 will nearly reach magnitude 10 — stimulating our retinas as much as the galaxies that comet hunter Charles Messier discovered.

First seen in 1873, Tempel 2 will gently arc near the leftmost of three bright stars along the bottom of Ophiuchus. From an orbital perspective, it's on a southerly track that sails just outside the orbit of Mars to cross the somewhat flat expanse of the solar system's plane (the ecliptic) next month.

Like all faint fuzzballs, comets require dark skies to observe. For the first two weeks of July, the moon will be in the evening sky hindering the view. Remember to try a variety of magnifications. At low power you ought to see that Tempel 2



Chris Schur



is not round, and higher power will permit you to see a brightening core. What else awaits? Comets are notoriously unpredictable, and outbursts last but a few hours, so take a look for yourself.

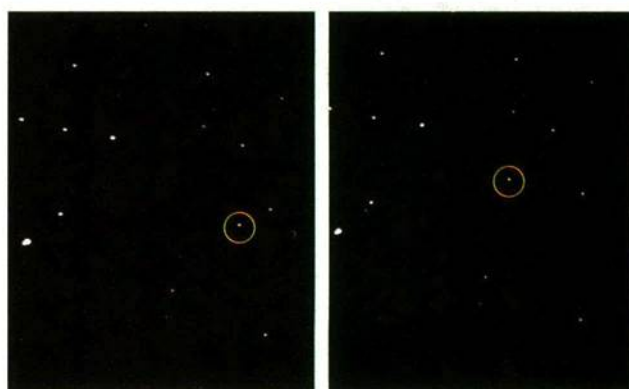
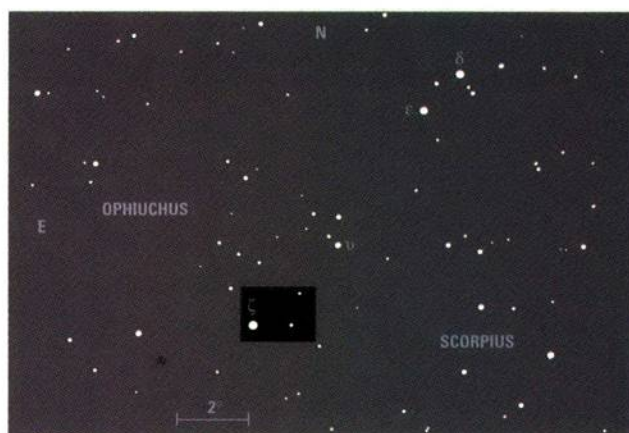
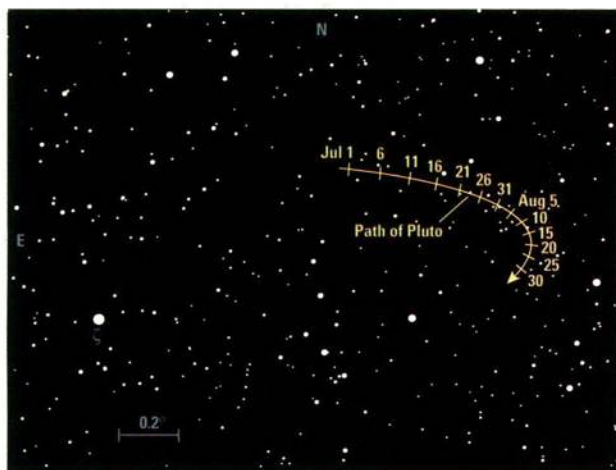


## OBSERVER'S CHALLENGE: Easy Pluto

If there is a year to easily find and track diminutive Pluto, this is it. The planet is a mere  $1^\circ$  to  $2^\circ$  hop from the bright star Zeta ( $\zeta$ ) Ophiuchi — better known as the middle of the three bright stars along the base of the constellation Ophiuchus.

At magnitude 13.7, Pluto must be sought out with care. A dark sky and an 8-inch telescope are typically considered necessary for success. One of the best tools in finding Pluto is the use of a dark cloth over the head to block out stray light. Then push the magnification to more than 150 to 200x.

Start your observation by first targeting the right area. Begin at magnitude 2.6 Zeta and shift exactly  $1^\circ$  (two moon widths) west to a 7th-magnitude star. If you're not sure which way is north, gently nudge your scope toward Polaris and watch which way the new stars come into the field of view. A straight line of three 10th-magnitude stars lined southeast to northwest lies  $0.5^\circ$  to the north. These three will be your reference points. They will help in spotting Pluto's gradual displacement across the starfield.



Paul Roques

With a big scope and a deep star chart, it's easy to find Pluto. The tried and true method is to make a sketch of the field and then come back on a following night to see which faint "star" moved.

From July 5 to July 7, Pluto slides south of two 13.1-magnitude stars and is just a tad fainter. Next year Pluto begins approaching the Milky Way and continues to fade as it moves farther out in its orbit. The time to observe is now.

The beginning of the partial lunar eclipse is visible from most of the United States. East coast observers see first contact with the umbral shadow of Earth as the moon sets, while the entire eclipse is visible from the Pacific coast and the Hawaiian islands. The event begins at 10:22 UT or 3:22 A.M. Pacific Daylight Time (PDT). Maximum eclipse occurs at 4:34 A.M. PDT, and ends at 5:46 A.M. PDT.

At maximum, 40 percent of the moon's diameter will be in shadow.

Observing **Jupiter** and **Saturn** calls for an early start in July. By 3 A.M. local time, both planets are well clear of the horizon. Saturn's rings present their widest guise since 1991 — showing off a  $20^\circ$  tilt to earthbound observers. There isn't much time to take in the view as the brightening eastern horizon indicates dawn is fast approaching. Jupiter

and Saturn are only  $12^\circ$  apart and both lie within the constellation boundaries of Aries the Ram.

Finally, observers in the extreme northeastern United States might be able to see the occultation of Aldebaran by a waning crescent moon on the morning of July 10. The event for Boston occurs within minutes of moonrise, which leaves little room for adjusting the telescope. You will need an exceptionally clear view to the eastern

horizon (find a coastal observing location with a view out to sea) to see the event. It occurs shortly after 3 A.M. Eastern Daylight Time. For observers in northern Europe, the event may be seen in daylight. **A**

*Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.*



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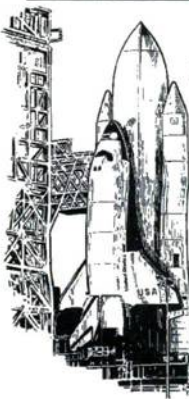
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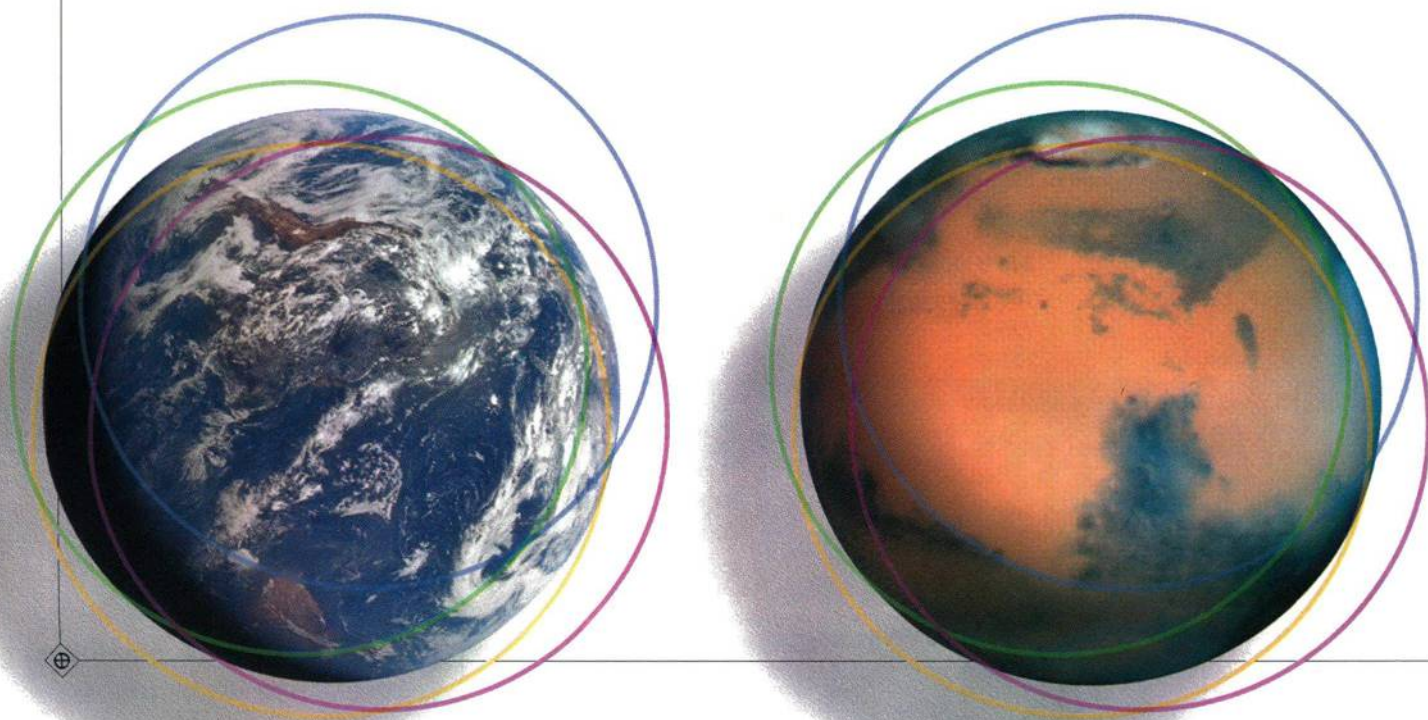


# REASONS FOR

*Why are summers so hot and winters so cold? The answer to this seasonal*

**A**t northern latitudes, this is the time of year when the sun sweeps an extended arc across the sky. The days are long, the nights are short, and children invariably plead to stay up past their bedtimes. After all, fireflies need to be captured in mayonnaise jars and flashlight tag has to be played in the humid night air. When I was 4 or 5 years old, I couldn't understand why my mother made me go to bed while it was still light out. By about 8:30 P.M., already past my 8 o'clock bedtime, the sky was still a deep blue with shades of pink. I fought to stay up, but my mother rarely relinquished. "The sun is putting on her pink nightgown, and it's time you do the same," she'd reply. My head would hit the pillow in a huff, though my eyes never stayed open long enough to make it past twilight's glow. I didn't understand why it was okay to stay up way past sunset in winter, but during the summer months I had to go to bed in daylight. It just didn't seem right.

To help quell this evening battle in your own home, start with the basics of how Earth moves in the solar system. Earth revolves around the sun once every 365.26 days. As it races





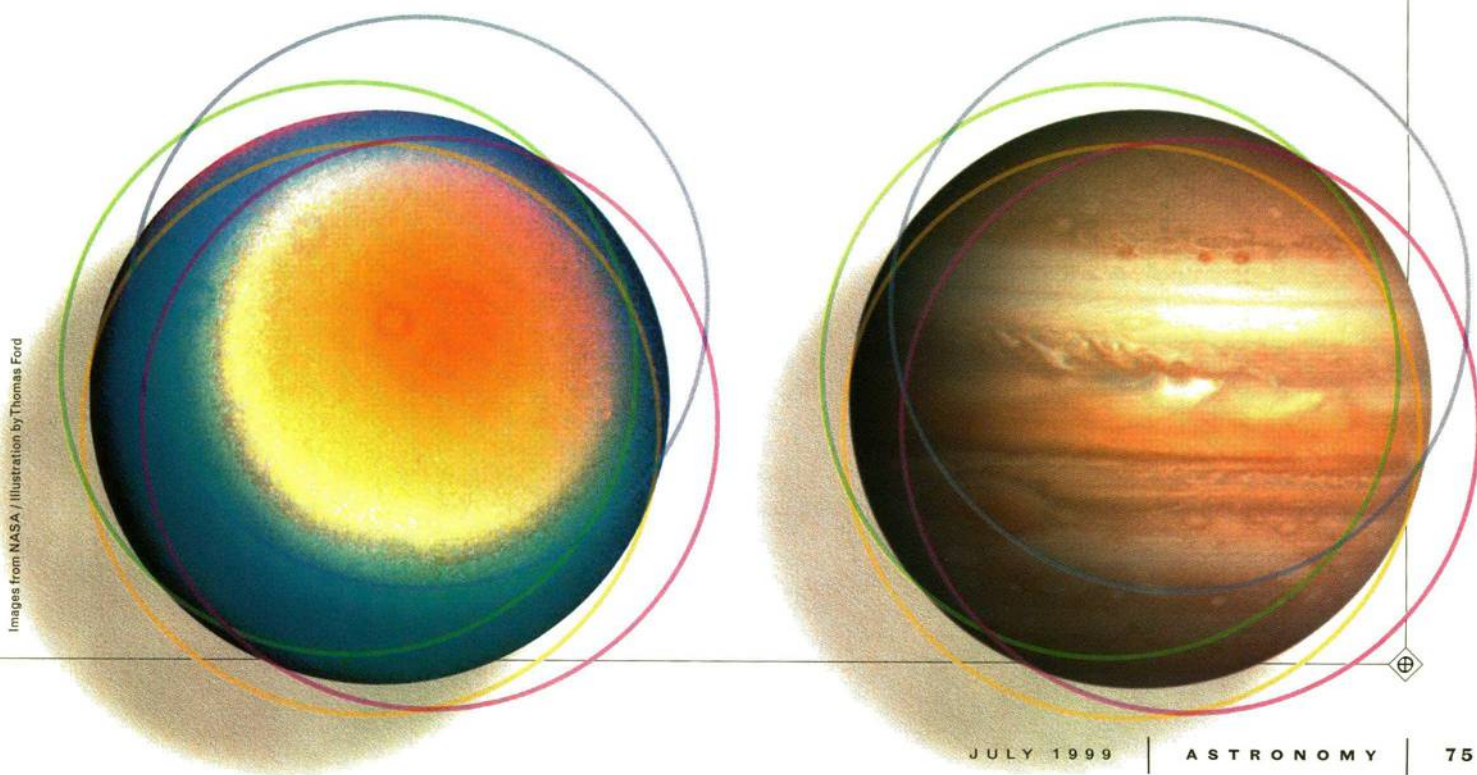
# THE SEASONS

*question isn't as simple as you might think.*

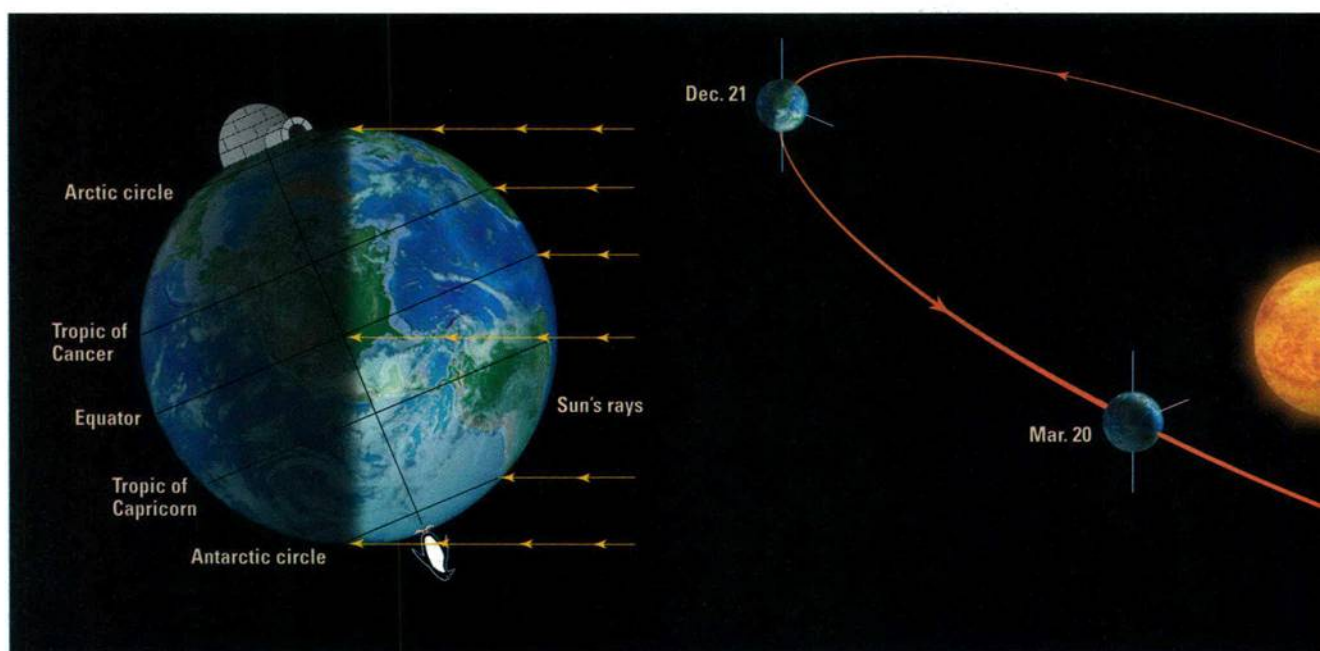
*by Andrea Gianopoulos*

along at 18.5 miles per second, the sun appears to move through our sky. It follows a path called the ecliptic, which passes through 12 constellations (one for each month) known collectively as the zodiac. Though close to a perfect circle, Earth's orbit has a very slight eccentricity, or oval shape, to it. This slight elongation has led to some significant misconceptions. Most people picture Earth's orbit as an exaggerated ellipse with the sun at one focus. With this in mind, it's easy to understand why many believe the seasons to be the result of Earth's position relative to the sun. After all, it makes perfect sense that Earth must be closer to the sun in summer and farther away in winter. Yet nothing could be further from the truth. Yes, it's hotter during summer months, but we are actually at our farthest point from the sun in July and at our closest point in January. Why, then, is it so hot in July and cold in January? The answer is in the tilt of Earth's axis.

**Earth and Mars (opposite page) have much in common, including the nearly identical tilt of their axes of rotation. This results in very similar seasons on the two worlds. The axis of Uranus (left) lies in the plane of its orbit, so it experiences the solar system's most extreme seasons. With an axis perpendicular to its orbit, Jupiter (right) has no seasons.**







Earth spins about an imaginary rod called an axis, taking 24 hours to complete one rotation. The axis is not vertical to Earth's orbital plane around the sun, however, tilting  $23.4^\circ$  from straight up and down. It's this tilt that gives us the seasons.

As Earth orbits the sun, the tilt of its axis determines how sunlight hits the surface. From about May through July, the Northern Hemisphere points toward the sun. The sun travels along an elevated arc — rising in the northeast, standing high in the south at noon, and setting in the northwest — which translates into much longer days. Even more important, the sun's rays strike Earth at a much higher, or more direct, angle than they hit the Southern Hemisphere. Six months later, when the Northern Hemisphere points away from the sun, we're in the midst of winter. The sun makes a low arc across the sky, rising in the southeast and setting in the southwest, and, even at midday, the sun's rays strike the surface obliquely.

The changing angle of the sun in the sky, brought to us by the tilt of Earth's axis, drives the seasons. Consider a person who lives at  $40^\circ$  north latitude. At local noon on the first day of summer, the sun lies a scant  $17^\circ$  from the zenith (the  $40^\circ$  latitude minus the  $23.4^\circ$  tilt of the axis). On the first day of winter, however, the noontime sun lies a whopping  $63^\circ$  from the zenith ( $40^\circ$  plus  $23.4^\circ$ ). From that angle, sunlight spreads out over an area more than twice as great as it does on the first day of summer — and so delivers less than half the amount of heat.

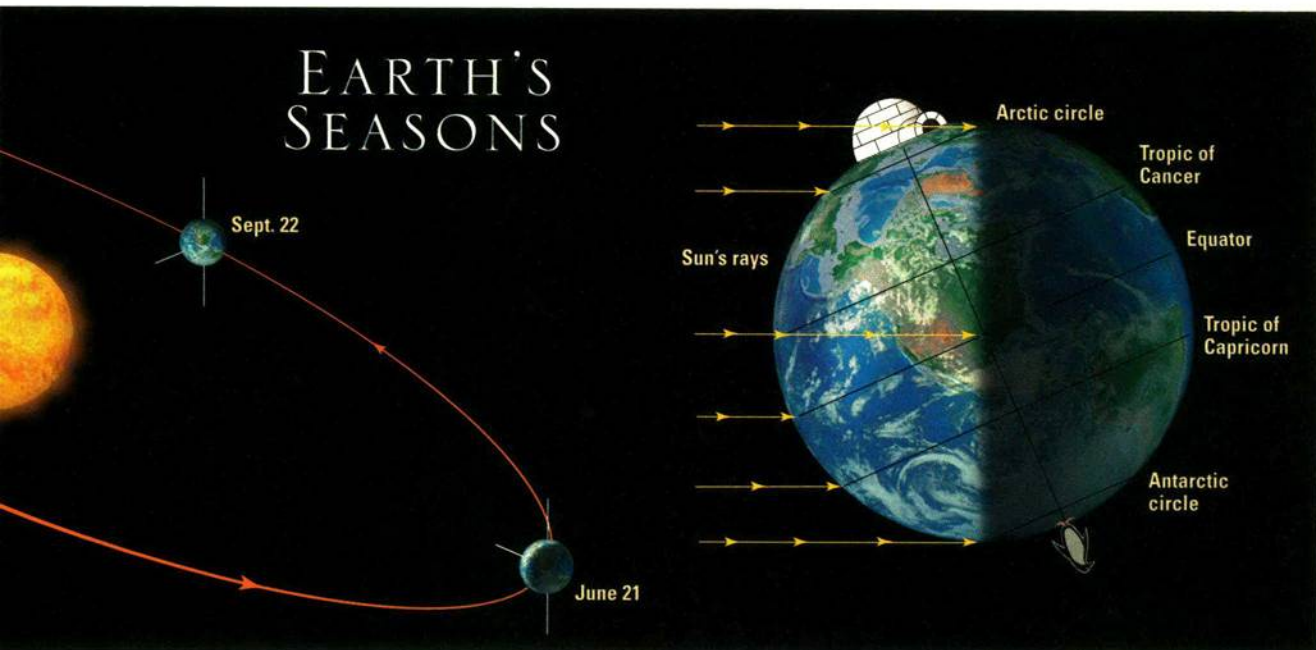
It's hard to envision all this rotating, revolving, and tilting, particularly for children. The best way to explain these concepts is to let the kids reproduce the motions themselves. Start with a flashlight and a globe — though any round object, such as a blue ball with the continents and North and South Poles drawn on it, will do.

#### PLANETARY ROLE-PLAYING

Have one child hold the globe while you or another child holds the flashlight. Turn on the flashlight and point its beam toward the globe. Slowly spin the globe counterclockwise to illustrate Earth's rotation. Point out how the sun appears to move across Earth's surface — just like it appears to move across our sky. When the beam reaches the East Coast of North America, the West Coast still lies in darkness. The sun is rising in the eastern part of the country just as it rises in the eastern part of the sky. Bring home the point that Earth's rotation makes the sun appear to rise in the east, move across the sky, and set in the west. Remember to mention that the stars, moon, and planets appear to rise and set as well.

Once Earth's daily motion is fixed in their minds, it's time to explain the yearly motion. Have one kid play the role of the sun and another the role of Earth, while any others can be the stars of the galaxy. The Earth-child should move around the sun-child, and make sure the sun follows Earth with the flashlight beam. You may also have to remind the sun not to flash the beam into Earth's eyes. Ask lots of questions, particularly of the child pretending to be Earth. "What do you see as you





rotate?” As Earth faces the sun she sees daylight, as she faces away she sees the night sky. The stars are still there during daylight, but the sun outshines them. “Does the sky change as you revolve around the sun?” Because stars lie all around her, she will notice a change in the sun’s position relative to the background objects. Have the child pretending to be Earth comment on how the sun appears to move with respect to the other objects in the room, then explain how the same earthly motion gives us different sets of stars in different seasons.

Now that you’ve led your children through the process, let them try it on their own. Ask Earth to show a year’s worth of motion. Invariably, she will rotate on her axis a couple of times while circling the sun. Make sure to point out that she should have rotated 365 times (once for each day) as she circled the sun once (one year).

The next point to tackle is the axial tilt. Have the Earth-child stand like a stiff board with her feet together. Now make her lean back, pivoting on her heels while you brace her from falling. Tilt her back roughly  $23^\circ$  and ask her to rotate 365 times while revolving around the sun once. Most children will accept the challenge until they realize just how hard it is to accomplish.

#### OTHER PLANETS

To better understand how these same motions work on other worlds, let the kids pretend to be other planets. Start with Mars, because it’s so similar to Earth. Mars spins on its axis just a little slower than Earth does, completing one rotation in 24 hours and 37 minutes. And

with an axial tilt of  $25.2^\circ$ , just  $2^\circ$  more than Earth’s, it has similar seasons. But its year is 1.88 Earth years long, so each season on Mars lasts roughly six Earth months.

The fifth planet from the sun, Jupiter, behaves very differently. This giant spins faster than any other planet, taking 9 hours and 50 minutes to rotate once, while its year takes 11.86 Earth years. Though Jupiter has a short day and a long year, it doesn’t have seasons like Earth and Mars. Its axis tilts just  $3.1^\circ$ , so it spins nearly straight up and down and both its northern and southern hemispheres receive nearly the same amount of sunlight.

Uranus is another oddball. It orbits the sun once every 83.75 Earth years, and spins on its axis once every 17 hours. What makes it so strange is its  $97.9^\circ$  axial tilt. Uranus orbits the sun more like a barrel on its side than a spinning top. Its seasons and days are very bizarre, at least from our earthly perspective. When the northern hemisphere points toward the sun, the southern hemisphere is in complete darkness. The only time both hemispheres experience day and night is at the equinoxes, and each season goes on for 21 years.

There you have it, the reasons for the seasons. Though the explanation may not stop those evening battles, all of that rotating, revolving, and tilting will — with any luck — wear your little one out. She’ll be fast asleep before her head hits the pillow, leaving you to prepare for a long night of observing. **A**

*Andrea Gianopoulos is an associate editor for Astronomy.*



# Draco



*The celestial dragon  
guards a treasure of  
galaxies and double stars.*

by Tom Polakis

IT IS DIFFICULT TO OBSERVE THE constellation Draco the Dragon in one season. The tail end of Draco slithers between the Big Dipper and Little Dipper, which are frequent spring observing targets. Draco's midsection reaches an area north of Cepheus that is overhead on autumn evenings. This winding constellation finally tops off above the summer constellations of Hercules and Cygnus. All told, Draco's string of stars wraps halfway around the North Celestial Pole.

The most recognizable asterism in Draco is a four-star trapezoid north of the Keystone of Hercules that defines the head of the dragon. Draco's brightest star is Eltanin (Gamma [ $\gamma$ ] Draconis), an orange, spectral type K star of 2nd magnitude, 150 light-years distant, which burns as brightly as 180 suns. Another star in the constellation brighter than 3rd magnitude is Rastaban (Beta [ $\beta$ ] Draconis), which also composes part of the dragon's head. The Alpha ( $\alpha$ ) designation of Draco goes to Thuban, a rather unimposing star that can be found between the bowl of the Little Dipper and the handle of the Big Dipper. Thuban's notoriety lies in its distinction as a former pole star; 4,800 years ago, the wobble of Earth's axis put Thuban within 10' of the North Celestial Pole.

NGC 3147 is a face-on spiral galaxy found by beginning at the bright galaxy M81 in Ursa Major and panning north-northeast about five degrees. It's unmistakable when found, showing a very bright, small core and a surrounding circular haze. Although spiral structure is not visible, the aspect of the core and halo are telltale signs that this is a spiral galaxy.

Redshift measurements place NGC 3147 at about 40 million light-years. United Kingdom astronomer Stephen Laurie discovered a supernova before maximum light in NGC 3147 using a 10-inch scope and a CCD camera. At discovery, the magnitude was measured at about 16, but it brightened by a magnitude and a half over the following week.

Located near the Ursa Major border lies another spiral galaxy, NGC 3735. The spiral tilts only 13° from edge-on, easily apparent through the eyepiece. With a 10-inch telescope, the galaxy appears less than 1' thick but four times as long. Even at a distance of 100 million light-years, NGC 3735 reveals a very bright, slightly elongated core.

Use an equilateral triangle extending upward from the top stars in the bowl of the Big Dipper to locate the elliptical galaxy NGC 4125. Recent observations by the ROSAT x-ray satellite show two crossing disks near the center, suggesting this galaxy may be in a new class of ellipticals that formed due to mergers. An 8-inch telescope brings out a bright, broadly concentrated oval core with a surrounding haze. Larger apertures extend the length of the elliptical galaxy to 4', and some observers have even noted a sharp nucleus.

I used a trio of faint stars at the end of the dragon's tail to locate the nearby galaxy NGC 4236. Hardly bright through any aperture, this member of M81's galaxy group deserves close scrutiny. At only 10 million light-years away, this typical spiral galaxy occupies half a medium-power field of view. It appears as a ghostly mist six times as long as its width. Larger telescopes reveal a number of faint knots that are



star-forming regions similar to our galaxy's Orion Nebula. If you have access to a 13-inch or larger telescope, look for the brightest of these HII regions at the south end of the spindle.

**NGC 4319** would not be worth mentioning as a visual deep-sky object were it not for the presence of an enigmatic quasar, Markarian 205, embedded in its envelope. The presence of a high-redshift quasar so near what appears to be a "host" galaxy adds fuel to the argument that the large redshifts of quasars may not be due to their great distance. Visually, the galaxy is nothing more than a circular glow, 2' across, showing a bright center. But it acts as a guidepost for the quasar 40" to the south of its center. French observer Yann Pothier was able to see Markarian 205 as a faint star through an 8-inch Schmidt-Cassegrain telescope. The quasar may be visible through even smaller apertures in good conditions.

Only 1.5° southeast of NGC 4319 lies **NGC 4589**, a bright elliptical galaxy. Despite its 60 million light-year distance, a Hubble image turned up over 200 globular clusters in the central 10,000 light-years of the galaxy. Through a 13 inch, a bright central disk comes into view, surrounded by a much darker oval halo 2' by 1' across. The spindle of the faint spiral galaxy NGC 4572 glows dimly only 7' west-northwest of NGC 4589.

The glowing galaxy NGC 5866 may or may not be known as **M102** depending on whom you ask. Some sources argue that M102 is simply a duplicate observation of M101.



Martin C. Germano

NGC 4319 and Markarian 205



NGC 5907

James R. Foster, Michael A. Stecker, and William Fletcher

Others make a convincing case that it is NGC 5866. Perhaps the best summary on the topic may be found in Hartmut Frommert's excellent Messier Catalog website at <http://www.seds.org/messier/pub/info/messier/m102d.txt>. This lenticular shows up nicely in a 4-inch instrument as a bright streak 2' long with a brilliant center. On the best nights, a 10 inch reveals a thin dust lane extending almost as long as the galaxy.

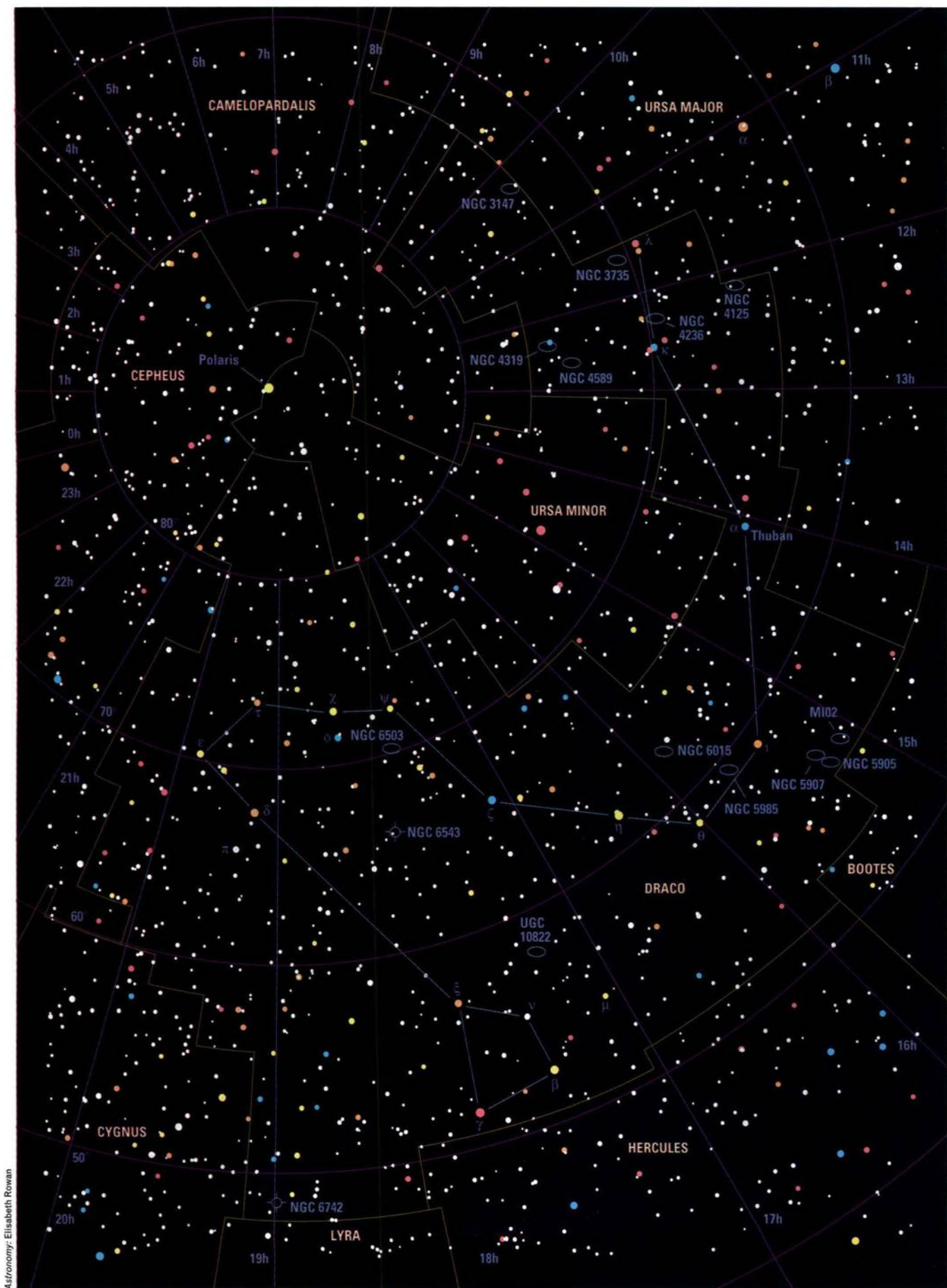
A 1.5° sweep to the east-northeast of M102 locks in the magnificent edge-on galaxy **NGC 5907**. Lying 35 million light-years away, it is physically grouped with M102. The plane of NGC 5907 tilts only 3.5° from our line of sight. The author of *1000+ The Amateur Astronomer's Field Guide to*

*Deep Sky Observing*, Tom Lorenzin, calls this galaxy a silver sliver and sees it as 11' by 0.6' in extent. Small scopes will provide a pleasing view of the long, narrow center, while increasing aperture extends the apparent length.

Less than 1° to the south is the visually small spiral galaxy **NGC 5905**. Through a 10-inch telescope, it's a circular halo that extends just 3' across. The faint spiral structure that doubles its size eluded my 20-inch telescope at a dark site. Though it may appear small and unspectacular to the eye, it is 400,000 light-years across, one of the largest spiral galaxies known.

**NGC 5985** is an ordinary spiral galaxy on its own, but it teams up with two other galaxies for one remarkable view. It is about 2' by 1' and elongated







in a north-south orientation. A 16-inch telescope may show some mottled detail of the multitude of spiral arms. Averting your vision only 7' to the west brings your gaze to NGC 5982, an elliptical galaxy scarcely 1' across, but the easiest of the trio to see. Scan nearly this same distance and in the same direction to find NGC 5981. An 8-inch scope may be required to show its dim, narrow form. The entire trio is best seen at medium magnifications.

NGC 6015 can be tracked down using triangulation with the bright stars Theta ( $\theta$ ) and Iota ( $\iota$ ) Draconis. A galaxy with a large, oval haze and a broad central brightening greets the eye in an 8-inch scope. In larger aperture telescopes, observers will be able to catch a glimpse of the surface, peppered with very faint knots.

From here we enter the more navigable head of Draco. The northwestern star of Draco's head, Nu ( $\nu$ ) Draconis, is a double star that's an easy split for the smallest scopes. These are two nearly identical blue-white stars of spectral type A situated 100 light-years from Earth. They are separated by just

under 2,000 astronomical units (1 AU = 93 million miles). Average binoculars on a tripod provide enough magnification to show Nu's duplicity.

Four degrees to the west lies a double that will require a telescope. Mu ( $\mu$ ) Draconis is a binary star orbiting with a period of 672 years. These stars are also of equal brightness but separated by only 2". Use magnifications greater than 200x and wait for a night when the images don't appear to be boiling. Often these nights are not coincident with the nights of the best transparency. When viewing the pair, note that they are separated by a distance that is easy to fathom: only 60 AU, or the diameter of Neptune's orbit.

If you aren't daunted by extremely faint objects, the **Draco Dwarf Galaxy** (UGC 10822) is a worthy target. It is truly a dwarf among galaxies, measuring only 1,500 light-years across. Even among the known dwarf galaxies it is considered small, perhaps better thought of as a large globular cluster. Its distance of only 230,000 light-years places it in the Local Group of galaxies. Studies of its orbital motion about the



Milky Way Galaxy suggest that it may have once been a part of the Large Magellanic Cloud, now situated on the opposite side of the sky. The keys to seeing the Draco Dwarf are dark, transparent skies and a lot of aperture. Its light is spread out over nearly a full degree, so use your lowest magnifications and sweep, looking for a subtle enhancement of the field. Hard-core observers report clumps of resolved 18th-magnitude stars on the surface.

It may only be of academic interest to mention the bright star Chi ( $\chi$ )

## Deep-Sky Objects in Draco

| Object       | R.A. (2000.0) | Dec.   | Mag.    | Size/Sep./Per. | Type | Notes            |
|--------------|---------------|--------|---------|----------------|------|------------------|
| NGC 3147     | 10h16.9m      | 73°24' | 10.6    | 4.3' by 3.7'   | Gal  | SA(rs)bc         |
| NGC 3735     | 11h36.0m      | 70°32' | 11.9    | 3.9' by 0.9'   | Gal  | Sac              |
| NGC 4125     | 12h08.1m      | 65°11' | 9.7     | 6.1' by 5.1'   | Gal  | E6               |
| NGC 4236     | 12h16.7m      | 69°28' | 9.6     | 21.0' by 7.5'  | Gal  | SB(s)dm          |
| NGC 4319     | 12h21.7m      | 75°19' | 11.9    | 2.8' by 2.1'   | Gal  | SB(r)ab          |
| NGC 4589     | 12h37.4m      | 74°12' | 10.7    | 3.0' by 2.7'   | Gal  | E2               |
| M102         | 15h06.5m      | 55°46' | 9.9     | 6.6' by 3.2'   | Gal  | SA0              |
| NGC 5905     | 15h15.4m      | 55°31' | 11.7    | 4.3' by 3.3'   | Gal  | SB(r)b           |
| NGC 5907     | 15h15.9m      | 56°20' | 10.3    | 11.5' by 1.7'  | Gal  | SA(s)c           |
| NGC 5985     | 15h39.6m      | 59°20' | 11.1    | 5.3' by 2.9'   | Gal  | SAB(r)b          |
| NGC 6015     | 15h51.4m      | 62°19' | 11.1    | 6.4' by 2.2'   | Gal  | SA(s)cd          |
| Mu Draconis  | 17h05.3m      | 54°28' | 5.7/5.7 | 1.9"           | Dbl  | 672 year period  |
| UGC 10822    | 17h20.2m      | 57°55' | 9.9     | 51.0' by 31.0' | Gal  | E pec            |
| Nu Draconis  | 17h32.2m      | 55°11' | 4.9/4.9 | 61.9"          | Dbl  |                  |
| NGC 6503     | 17h49.4m      | 70°09' | 10.3    | 7.3' by 2.4'   | Gal  | SA(s)cd          |
| NGC 6543     | 17h58.6m      | 66°38' | 8.1     | >18"           | PN   | Cat's Eye Nebula |
| Chi Draconis | 18h21.0m      | 72°44' | 3/?     | 0.135"         | Gal  | 0.768 day period |
| NGC 6742     | 18h59.3m      | 48°28' | 13.4    | 30"            | PN   | Abell 50         |

**Object:** Designation in Messier, NGC, or other catalog. **R. A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep./Per.:** Size in arcminutes or arcseconds, separation in arcseconds, or period in days. **Notes:** Hubble type for galaxies.



**Draconis.** No earthbound amateur telescope will resolve the binary companion of this 4th-magnitude star only 0.13" away, but it's at least interesting to view and consider. The orbital period of the system is not measured in years, but days. Every 287 days, the faint companion makes a revolution around the primary star.

Chi Dra also provides a nice hopping off point to reach **NGC 6503**. This bright spiral galaxy easily materializes in a 4-inch scope. Overall it is 4' by 1.5', showing a broadly concentrated region offset to the north of center. The surface mottling becomes very apparent in a 16 inch. Measurements of the brightest blue stars place NGC 6503 at 17 million light-years. The nearby galaxy is moving against the "Hubble flow" at 110 km/s.

**NGC 6543**, the Cat's Eye Nebula, is one of the finest planetaries in its class.



## The Dragon

*With vast convolutions Draco holds  
Th' ecliptic axis in his scaly folds.  
O'er half the skies his neck enormous rears,  
And with immense meanders parts the Bears.*

*Economy of Vegetation*

— Erasmus Darwin (1731–1802)

The large Dragon, whose lair is between the two Bears, is said to be the beast that guarded the golden apple tree. Gaea, or Gaia (Mother Earth), presented this tree to Hera on her wedding day, and Hera (the wife of Zeus) promptly had the tree planted in the garden of the gods near Mount Atlas. She charged the Hesperides, daughters of Atlas, as guardians of the tree and its fruit. Unfortunately, these sisters pilfered the apples at every opportunity. Hera knew she needed a ferocious sentinel to ward off thieves. So she placed the dragon Ladon around the tree. Enter Hercules, the son of Zeus. As one of his 12 labors, Hercules was told to steal some of the apples. To accomplish this feat, Hercules shot the dragon with poison arrows. Ladon fell from the tree, and Hercules gathered his prize.

— Andrea Gianopoulos



NGC 5985 Group

Kim Zussman

A star party favorite, many observers see its blue-green hue at first glance. Stepping up the magnification in a medium-aperture scope shows what can be described as spiral structure around the bright central star. The Cat's Eye is surrounded by a very faint outer shell 5' across that is a feature common to half of all known planetaries. This halo contains more mass than the core. Advanced amateur observers Rich Jakiel and Steve Gottlieb make note of observing a portion of this halo that resembles an elliptical galaxy a full 2' to the west of the central star. This bright part of the halo has been misidentified as a galaxy and even carries its own designation, IC 4677. Using an OIII filter in my 20-inch scope proved to me that the oval glow is in fact the "excited" light of a nebula and not a galaxy.

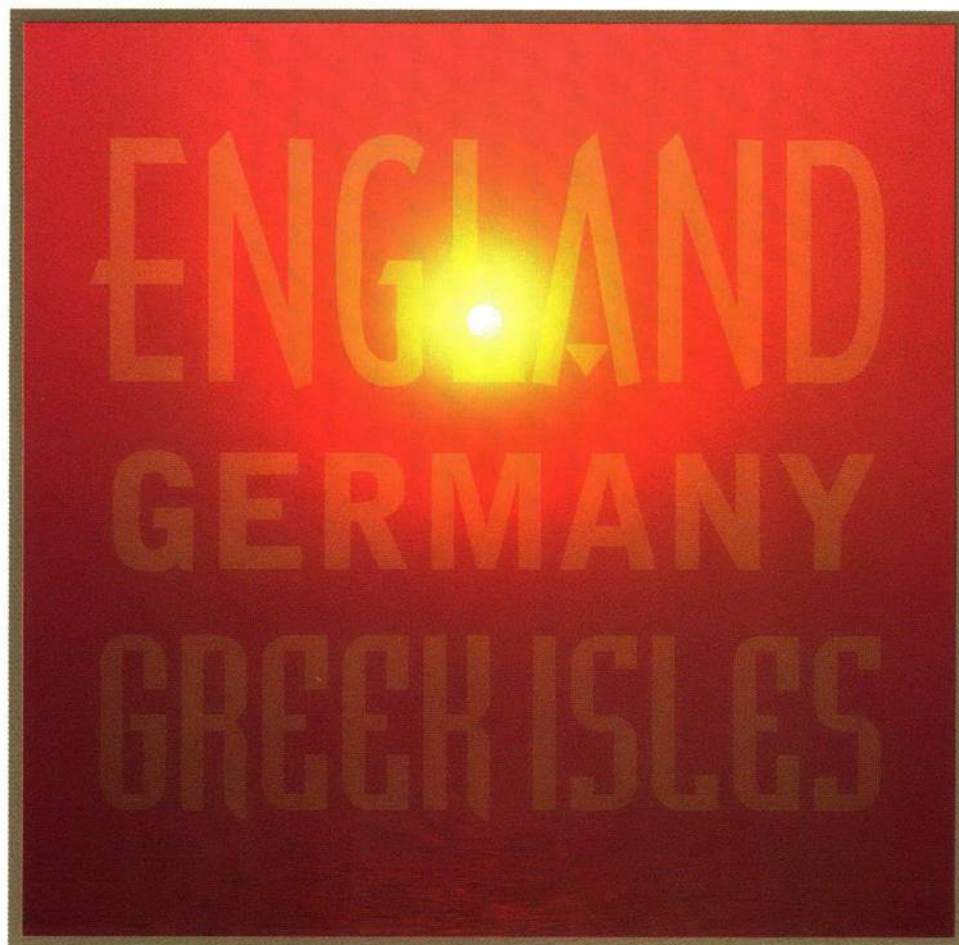
The neglected planetary nebula **NGC 6742** floats near the Cygnus border. Although faint, it is bright enough to show up in a 10-inch telescope as a sharp-edged, round disk. Try to spot the ring structure in this object. There are a multitude of astronomical wonders in this constellation. Viewing these hot spots in Draco the Dragon will breathe some fire into your observing evenings. **A**

*Tom Polakis is an aerospace engineer living in Tempe, Arizona. His favorite astronomical pursuits are deep-sky observing and photography.*



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# London



**W**HEN I HEAR THE WORD “LONDON,” MY MIND is flooded with a hundred images — palaces and pageantry, the Black Death and the Blitz, Dick Whittington and Jack the Ripper, tea-time scones and fish and chips. The Roman Settlement of Londinium (A.D. 43) has transformed itself many times over, from the seat of the Tudor Renaissance and the epicenter of the Industrial Revolution, to the epitome of the Swingin’ Sixties and now the liberal capital of Tony Blair’s “Cool Britannia.”

Though no longer the center of a vast British Empire, London remains an exciting international city. On an eavesdropping stroll from Buckingham Palace down The Mall, through Admiralty Arch to Trafalgar Square, a visitor is

almost certain to hear four or five languages — German, French, Turkish, Japanese, Arabic, and others more difficult to identify. There are also museums for every interest and restaurants for every taste. London has theaters, churches and cathedrals, historical landmarks and shops, shops, shops! There’s something for everyone — even an astronomer.

Every astronomer’s tour of London should begin at the **Old Royal Observatory** (part of the National Maritime Museum) at Greenwich. Hop on one of the boats that departs regularly from Westminster or Charing Cross piers and cruise leisurely down the Thames to where time begins.

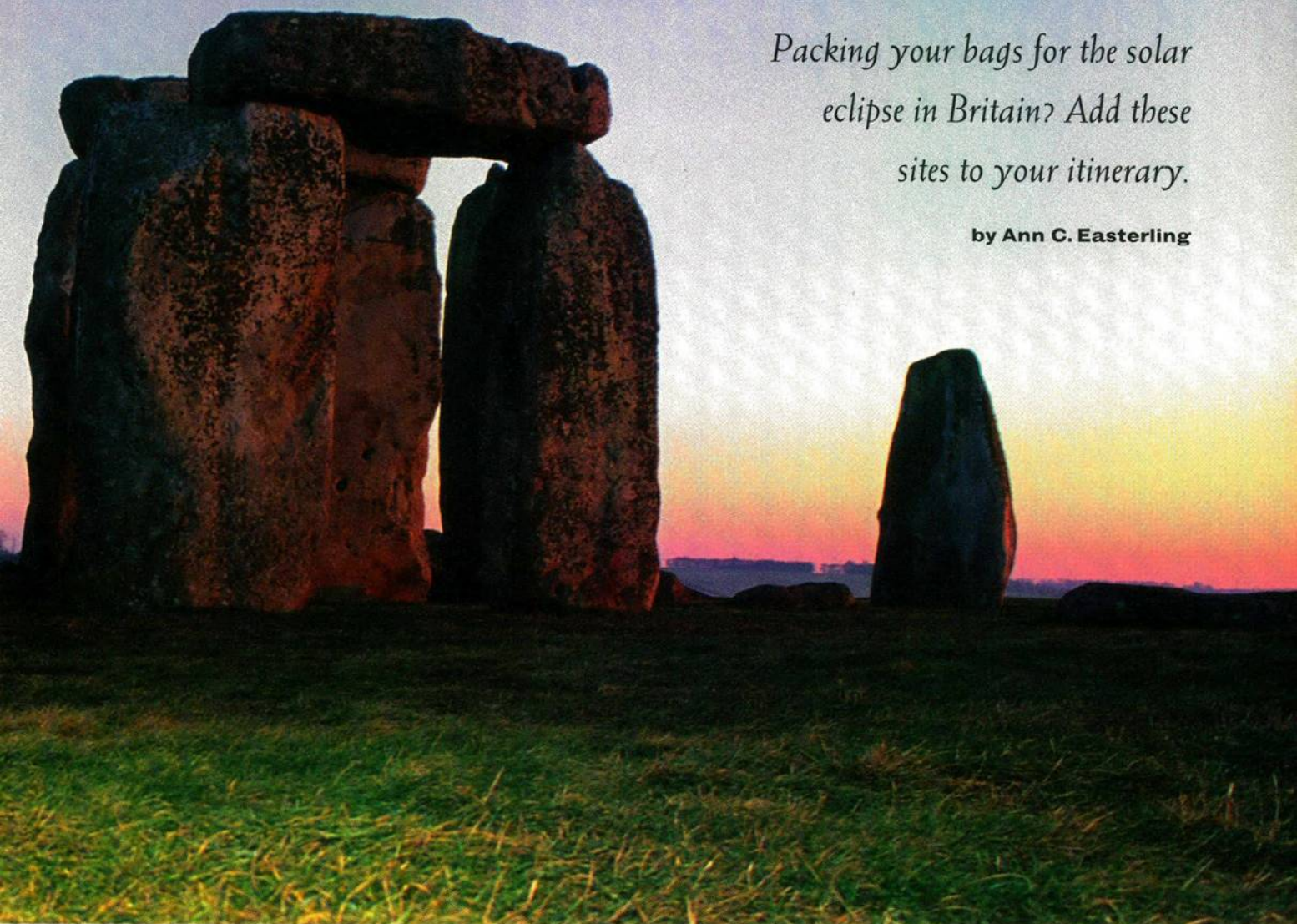
King Charles II, who was infamous for his extramarital liaisons, had a sincere interest in astronomy and the implications of accurate celestial navigation on England’s maritime



# Calling

*Packing your bags for the solar eclipse in Britain? Add these sites to your itinerary.*

**by Ann C. Easterling**



commerce. He founded the Greenwich observatory in 1675 and appointed John Flamsteed as the first Astronomer Royal.

Flamsteed House, designed by Christopher Wren (one of London's most prolific architects and a professor of astronomy and mathematics at Oxford) was the home of the Astronomer Royal from 1676 until 1948. Today the building is filled with a collection of telescopes, chronometers, timepieces, astronomical prints and paintings, and a few interactive exhibits. Upstairs, Wren's stunning Octagon Room features tall windows made to accommodate the long refracting telescopes of the day.

The Old Royal Observatory is best known as the place where measurements of time and longitude were first standardized by international agreement in 1884. The

observatory's Gate Clock shows Greenwich Mean Time, while the Meridian Courtyard holds the Prime Meridian ( $0^\circ$  longitude), which separates the Eastern and Western Hemispheres. The best time to visit the courtyard is precisely 1 P.M. when the Time-Ball atop the Flamsteed House tower drops — the Greenwich equivalent of New Year's Eve in Times Square. This daily ritual was begun in 1833 to allow ships on the Thames to set their chronometers. Before you leave the courtyard, be sure to get a photo of the kids with one foot in each hemisphere.

Exhibits in the Meridian Building track the many attempts to establish a true meridian. The building also houses a 1.5-ton, 28-inch Great Equatorial Refracting Telescope built in 1893. To this day, the telescope is the





The distinctive façade of Flamsteed House rises atop Observatory Hill. Look for the red Time-Ball to drop at precisely at 1 P.M. each day. National Maritime Museum, London

largest refractor in Britain and the seventh largest refractor in the world.

The Altazimuth Observatory houses a 6-inch Newtonian reflector that is used for public sunspot observations and star parties. Visitors can also experience multimedia planetarium shows in a converted observatory dome.

### Science Past

Another popular stop in London is the **National Museum of Science and Industry** on Exhibition Road south of Kensington Gardens. Start your visit on the third floor in the Geophysics Gallery. Here you'll find the 72-inch Rosse Mirror, the largest metal telescope mirror ever made. The mirror, housed in Lord Rosse's telescope at Birr Castle, Ireland, was made in 1845. It was the largest telescope in the world until the 100-inch Hooker telescope on Mount Wilson, California, acquired the distinction in 1914.

Step further back in time to discover how far we've come so fast. "Science in the 18th Century: The King George III Collection" presents the state of science in this "era of profound change." Inspired by the social revolution, George III acquired vast numbers of scientific instruments. Included in the exhibition are an orrery (1750) and an armillary sphere (1731) that demonstrates the Copernican theory of the universe, a glass celestial sphere (1742) that simulates the real and apparent motions of the heavens, and a pair of celestial and terrestrial globes (1766) made for the king by George Adams. Each of these instruments is an unparalleled model of design and craftsmanship.

Quite often history overlooks the contributions of women, especially in science, so I found the inclusion of Caroline Herschel's telescope in the exhibition a delightful surprise. The telescope was built by Caroline's brother William Herschel in 1795 according to her specifications. She

wanted it to look just like the telescope that William used to discover Georgium Sidus (George's Star) — the original and royally flattering name of Uranus.

Just beyond this array of early astronomical tools is the Optics Gallery. Here you'll find an impressive collection of telescopes, cameras obscura, field glasses, and lenses accompanied by explanations that give a clear and easy-to-understand overview of the topic. Also take time to visit the "Time Measurement" gallery on the second floor. With displays of Saxon sundials and medieval hourglasses, this exhibition presents the development of man's ability to gauge the passage of time. Make a beeline for the unbelievable reconstruction of Giovanni Dondi's 1381 Astrarium. This complicated timepiece is also a working model of the universe. Eight of its dials show the position of the sun, moon, and the then-known planets while the ninth displays the position of the lunar nodes (points where the paths of the sun and the moon intersect).

After exploring astronomy's past, delve into the present and future in "The Exploration of Space" (on the first floor). Investigate the current state of space science, remote sensing, satellite communication, remote space astronomy, infrared astronomical satellite experimentation, interplanetary space travel, and the solar-terrestrial relationship.





These astronomy-related exhibits are just a fraction of the museum's vast collection. If your family is interested in all things scientific, your visit to the Science Museum could take all day.

Northeast of the Science Museum is the **London Planetarium** on Marylebone Road just south of Regent's Park. Here "Planet Zone" features interactive exhibits and models of planets, artificial satellites, and spacecraft. You may also come face to face with Neil Armstrong, Galileo, and Stephen Hawking – well, sort of. Madame Tussaud's Wax Museum is next door.

## Astronomy in the City's Heart

The Old Royal Observatory, the Science Museum, and the London Planetarium are obvious stops on an astronomer's itinerary, but in London you can find astronomy in the most unlikely places — you just have to look a bit harder.

One such place is **Westminster Abbey**, the setting of coronations, royal weddings, and funerals

since 1066. Sir Isaac Newton was buried at the east end of the nave in 1727; look for the gilded Choir Screen which houses a tribute to him. Within a few feet from Newton's grave are the tombs of William and John Herschel, and the Cloisters hold a comet-shaped memorial to Edmond Halley. Other scientists buried here include Charles Darwin and the 19th century explorer David Livingstone. You may also see tributes to John Joseph Thomson and Ernest Rutherford, pioneers in the field of atomic physics. Keep in mind that Westminster Abbey is an active place of worship and certain areas are sometimes closed to the public. Ask the warding staff for information to locate specific memorials.

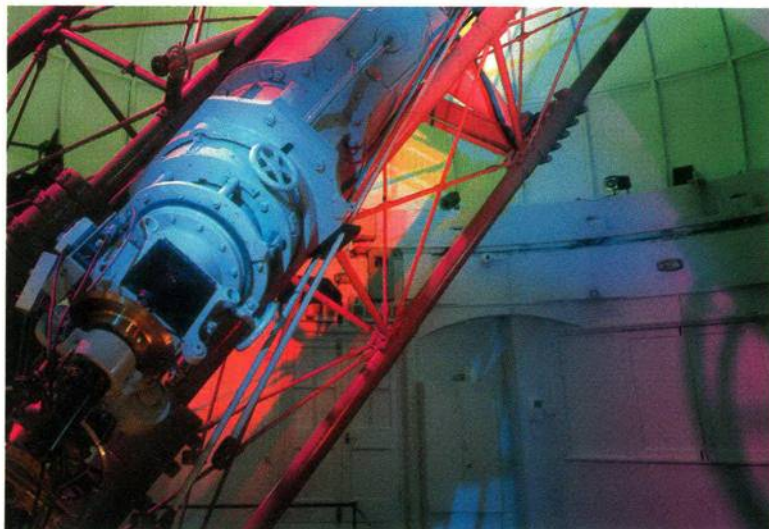
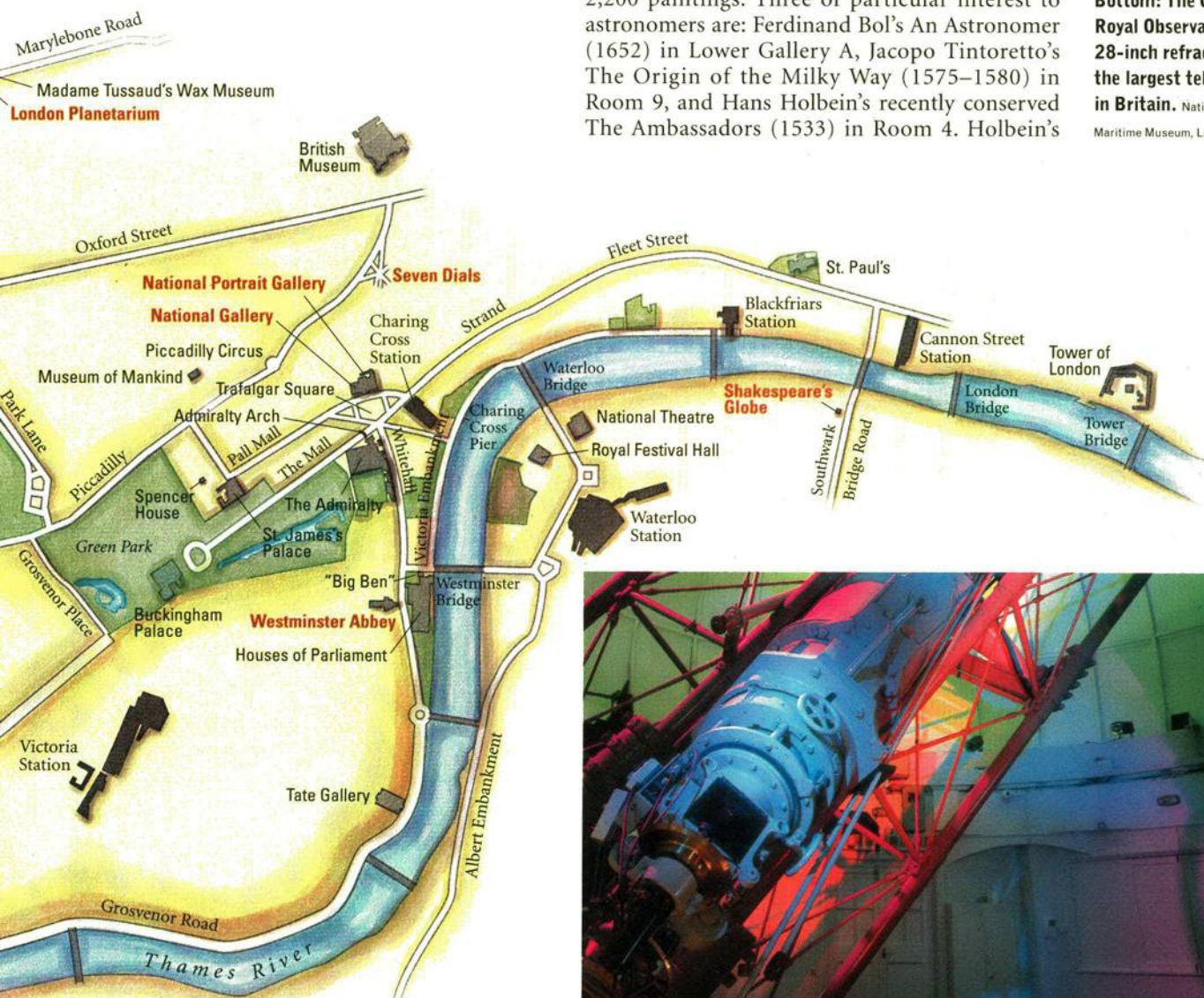
Located just off of Trafalgar Square are the **National Portrait Gallery** and **London's National Gallery**. Here you'll see great works by the likes of Leonardo da Vinci, Michelangelo, Cézanne, Degas, van Gogh, Picasso, and Monet, but you may seek out a few astronomical works as well. The National Gallery contains more than 2,200 paintings. Three of particular interest to astronomers are: Ferdinand Bol's *An Astronomer* (1652) in Lower Gallery A, Jacopo Tintoretto's *The Origin of the Milky Way* (1575–1580) in Room 9, and Hans Holbein's recently conserved *The Ambassadors* (1533) in Room 4. Holbein's

**Below left: The majority of London's astronomical sites are located at the city's center.** *Astronomy:*

Elisabeth Rowan

**Bottom: The Old Royal Observatory's 28-inch refractor is the largest telescope in Britain.** *National*

Maritime Museum, London





double portrait of Jean de Dinteville, French Ambassador to the court of Henry VIII, and Georges de Selve, Bishop of Lavaur, France, depicts a celestial globe, a cylindrical or shepherd's dial, quadrants, a polyhedral sundial, a torquetum, and a terrestrial globe. Although Holbein frequently consulted the King's astronomer Nicolaus Kratzer, some inaccuracies mar the painting. Look to the two quadrants to see if you can find the errors.

The National Portrait Gallery holds oil portraits of Christopher Wren (1632–1723) and Edmond Halley (1656–1742) in Gallery 6, and Isaac Newton (1642–1727) in Gallery 5. Also look for William Herschel (1738–1822) and check out the Victorian Portrait Photography exhibition to see an 1848 daguerreotype and 1867 photograph of William Herschel's son, John (1792–1871).

If you've never associated astronomy and theater, you're probably not alone. However, during Shakespeare's prime, the two subjects were inextricably linked. **Shakespeare's Globe Theatre**, just west of Southwark Bridge Road along the Thames, demonstrates the Elizabethan concept of theater as a reflection of the universe. Beneath the stage was the netherworld of ghosts and devils. The stage itself was the earthly domain of actors. Above all these was the heavenly sphere decorated with suns and moons, clouds and stars. The Globe's stunning canopy features a radiant sun nestled in a deep blue sky, surrounded by

smiling moons and the 12 zodiacal signs. It gives justice to Hamlet's words, "this brave o'erhanging firmament, this majestic roof fretted with golden fire."

Head back across the Thames to the east-northeast and Covent Garden. You won't find Eliza Doolittle selling flowers here, but you may discover the **Seven Dials** on Monmouth Street just off Shaftesbury Avenue. The column marks the intersection of seven streets.

It was erected in 1694, but was toppled in 1773 when tales of treasure buried beneath it ignited the greed of Londoners. The present copy of the 17th-century original only holds six sundials. The seventh is the column itself. Its shadow falls on the pavement below where the hours are marked by iron posts around the column's base.

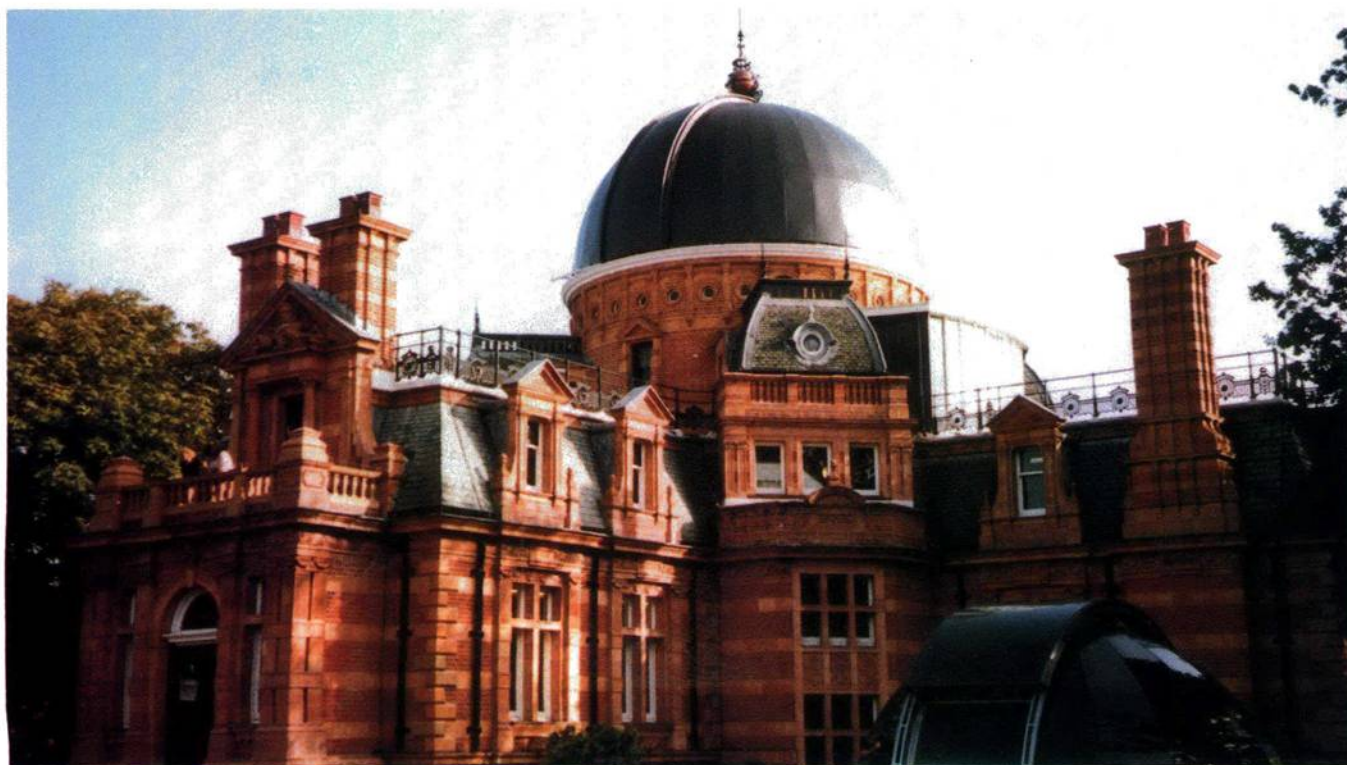
For a day of astronomy away from London's center, visit **Hampton Court Palace** in Surrey on the edge of southwest London, the backdrop for nearly 500 years of royal history. Cardinal Wolsey, Archbishop of York, began building this country home in 1514. So impressed was Henry VIII with its magnificence that he swiftly accepted Wolsey's generous and career-saving offer of the property. The king moved in 1525.

As you pass through Anne Boleyn's Gatehouse and enter Clock Court, turn around and look up. Overhead you'll see the famous Astronomical Clock designed for Henry VIII in 1540 by Nicholas Oursian, Devisor of the King's Horolo-



**Right: A portrait of Sir William Herschel as done by Lemuel Francis Abbott in 1785.** National Portrait Gallery, London

**Below: The dome atop the South Building at the Old Royal Observatory now houses a planetarium.** Astronomy: Andrea Gianopoulos







gies (clocks). Because the impressive golden clock was created before the discoveries of Galileo and Copernicus, it depicts the sun revolving around Earth. The geocentric timepiece indicates the hour, month, day, number of days since the beginning of the year, and phases of the moon. It is an amazing feat of 16th-century engineering and artistry.

Henry VIII was an avid astronomer who would view the night sky from the rooftop of the palace. As you roam throughout the gardens, kitchens, royal apartments, and palace's maze, let your mind wander back to the days when the skies were an intriguing mystery to royalty and commoners alike.

## Neolithic Astronomy

Even farther afield in the English countryside are the monuments at **Stonehenge** and **Avebury** in Wiltshire. Contrary to popular belief, neither was built by Druid cults during the Iron Age. In fact, they were built nearly 1,000 years earlier: Stonehenge, in stages from about 3,000 B.C., and Avebury from 2600–2100 B.C. Both Neolithic sites are worth a visit.

The orientation of Stonehenge to the rising and setting sun remains its mystery. Scholars continue to debate the possibility that the circle is part of an enormous astronomical calendar. An audio tour of the site describing the debate and the engineering skills involved in quarrying, transporting, and erecting the stones is available and recommended. Because of Stonehenge's popularity, the site has become crowded. Access to the stones is now prohibited, though plans to redesign the area for better public enjoyment are underway.

The astronomical significance of the stone circle, or "henge," at Avebury has not been identified — there are no obvious alignments. Unlike Stonehenge, the Sarsen stones at Avebury are natural and unworked. The henge and the surrounding burial barrows, avenues, ditches, and mounds create a ceremonial site that probably had more to do with death and regeneration than astronomy. In the present era, the site has always prompted questions and sometimes fear. Suspecting that the circle was a place of pagan sacrifice, 18th-century villagers smashed and charred the stones. At Avebury, you can walk among the stones to outlying barrows and mounds, imagining what the ceremonial site was like 4,000 years ago. The Alexander Keiller Museum, in the Village of Avebury, provides sound interpretation of the Neolithic landscape and the history of the site.

As you tour London, you'll discover many astronomical surprises all around you. After a day of starry sightseeing, you may want to relax a bit. In keeping with the astronomical flavor of your trip, try **The Man in the Moon Pub** in the fashionable King's Road in Chelsea near Beaufort Street. If you ask, the staff will cheerfully put extra ice in your soft drink, then ask in what part of America you live. But I say, "When in Rome..." so try some delicious hot chips and a pint (translation: fries and a beer). You'll feel very British indeed. **A**

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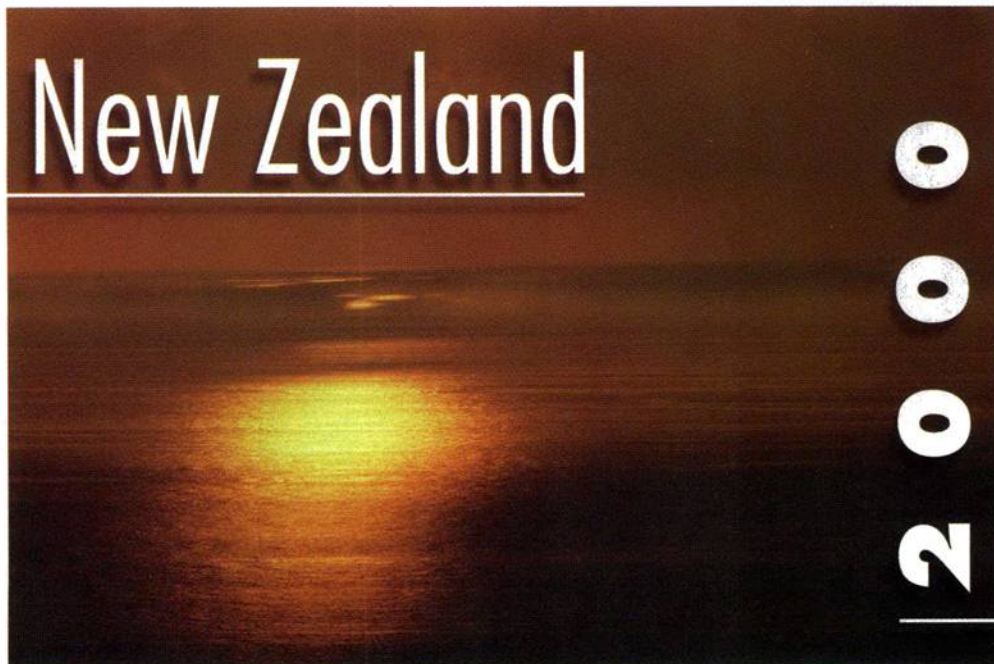
*Ann Easterling recently returned to the United States upon completion of her master's degree in museum studies at University College London.*

**The Octagon Room in Flamsteed House has changed little since it was built in 1675. The room holds portraits of Charles II and James I, as well as a quadrant and a working refractor that offers visitors an interesting view.** National Maritime Museum, London



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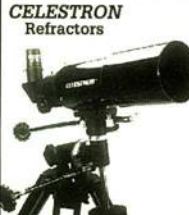


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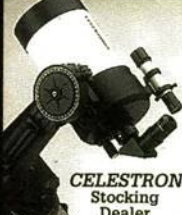
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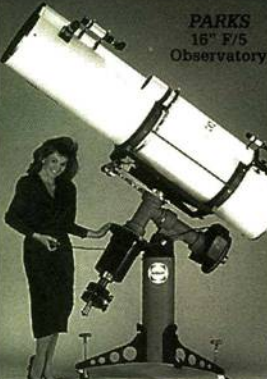
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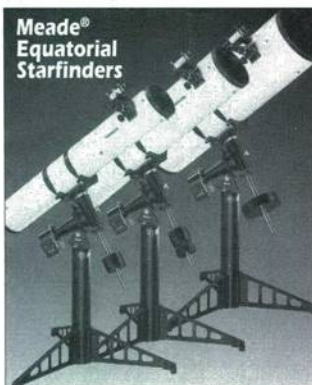
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| Giant Easy-Guider for 10"/12" f/4-f/10 ...  | \$395 |
| Dew Shields 8" .....                        | \$119 |
| 12" .....                                   | \$189 |
| 16" .....                                   | \$289 |

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|                                             |          |
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| Lumicon 2" Helical Focuser (1 1/2" high) .. | \$85.00  |
| 2" Astro systems focuser (only 2" high) ..  | \$149.00 |
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|                                            |         |
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|                                            |          |
|--------------------------------------------|----------|
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| UV/Dust Seal for Celestron 5"-9" .....     | \$39.00  |
| UV/Dust Seal for Meade 4"-8" .....         | \$39.00  |
| UV/Dust Seal (lg.) for Meade 10"-12" ..    | \$89.50  |
| UV/Dust Seal for Celestron 11"-14" .....   | \$89.50  |



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| 2" adapter for C-8, Meade 8-12" ..... | \$29.50 |
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|                                              |       |
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| 21mm F.L., 65° Apparent Field 1 1/4" .....   | \$269 |
| 28mm F.L., 55° Apparent Field 1 1/4" .....   | \$259 |
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|                                             |        |
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| Pronto 70mm f6.8 w/45° erecting prism ..    | \$925  |
| Tele-Vue 85,85mm f/7 APO telescope .....    | \$1995 |
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| 32mm Plossl, widest true field in 1 1/4" .. | \$110  |
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| 2" Giant Barlow - 2x .....                  | \$168  |
| 4.8mm Nagler 82° field, 1 1/4" * eyepiece   | \$175  |
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| 12mm Nagler Type 4, 82° 1 1/4" * or 2" ..   | \$340  |
| 16mm Nagler Type II, 82° 1 1/4" * or 2" ..  | \$310  |
| 17mm Nagler Type 4, 82° 1 1/4" * or 2" ..   | \$370  |
| 22mm Nagler Type 4, 82° 2" only .....       | \$415  |
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| 19mm Panoptic 1 1/4", 68° field .....       | \$240  |
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Note: TeleVue warranty may not be valid outside USA

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|                                       |                        |
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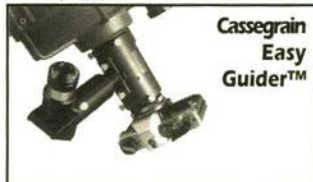
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# ask Astro

Universal Language, Earth without a Moon

**Q: The Pioneer 10 and 11 spacecraft launched in 1972 and 1973 carried plaques with pictorial messages from Earth. Since then, has any progress been made in developing a “universal language?”** — *George Krimsky, Washington, Connecticut*

**A:** Although a great deal of effort has been spent in thinking about how we might detect extraterrestrial societies, considerably less cranium power has been expended in concocting a scheme for interstellar communication. Perhaps that's because understanding may be a daunting task if the aliens are thousands of centuries more advanced than we are. Or perhaps it's because detection of a signal is the first priority

of enterprises such as SETI. Getting the associated message, if there is one, requires far more sensitive equipment. Understanding the message is yet further in the future.

The best known attempt to devise a universal language was made by the Dutch mathematician Hans Freudenthal. He described his language, called LINCOS, in a 1960 book of the same name. LINCOS begins with simple syntactical statements based on mathematics and physics (rather like the first alien messages in the movie *Contact*). However, the language gets considerably harder when used to describe social structures or behavior.

A more straightforward approach was taken with the Pioneer plaques and

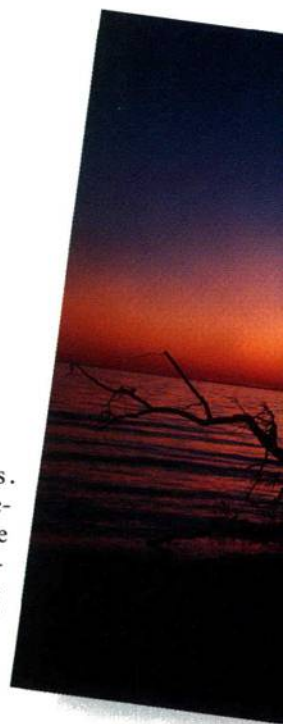
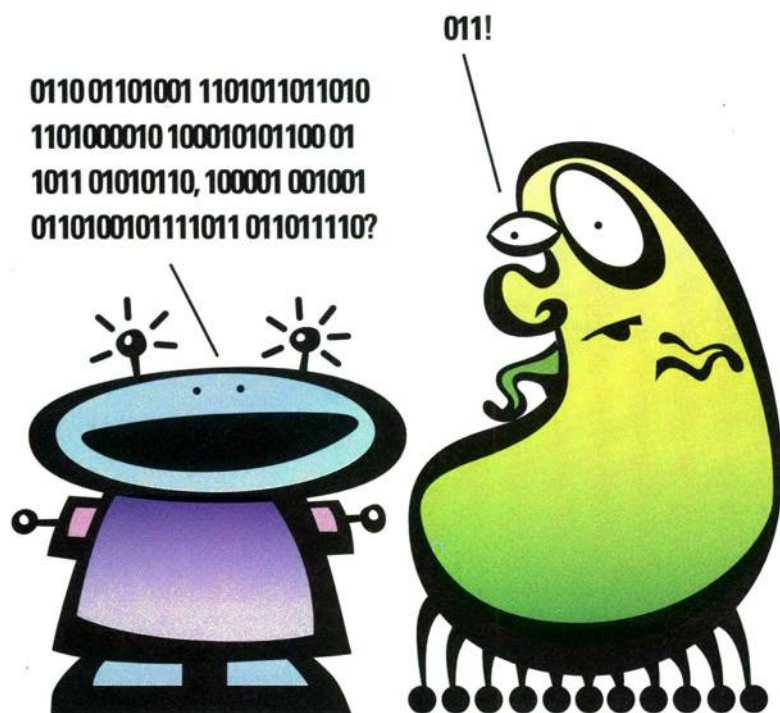
**Could we use math someday as a universal language?** *Astronomy: Terri Field*

Voyager records. These famous spacecraft, launched in the 1970s, carried easy-to-decipher sounds and images of earthly society. And indeed, it may be that in communicating with E.T., a picture is worth a thousand mathematical symbols. — *Seth Shostak, SETI Institute*

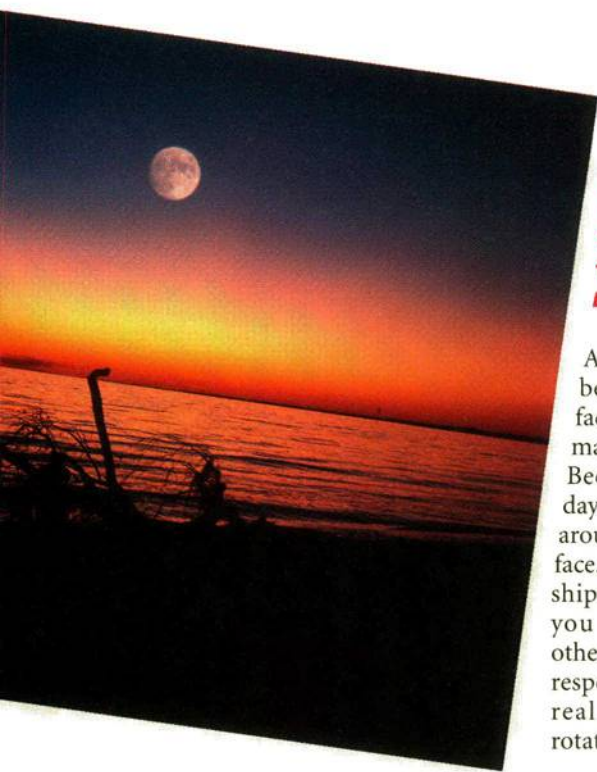
**Q: If Earth had no moon, how might early astronomers have perceived and explained the presence of natural satellites orbiting the outer planets?** — *Jeremy Daniel Jenkins, Clearwater, Louisiana*

**A:** It's an interesting “what if” question. Newton's theory of gravitation was inspired by his meditations on the falling apple; did gravity reach to the orb of the moon? Without the moon, it would have been harder to make this leap. The moon's motions provided the greatest challenge to the development of gravitational astronomy.

If Earth had no moon, satellites probably would have taken a little longer to work into an intellectual scheme; perhaps they would have been called “attendants.” In practical terms, they would have been seized on as a means of calculating terrestrial longitudes. Astronomers would have developed (as Cassini did for the satellites of Jupiter) empirical tables allowing ephemerides of their motions to be worked out. Eventually, astronomers would have discovered that Kepler's laws apply to the satellites as well as the planets, and they would







**The full moon shows only one side of its face to Earth. Does this mean it doesn't rotate?**

Larry Landolfi

have worked out such concepts as mass, gravitational force, and so forth. But it would have taken them longer to do so.

I don't know whether anyone has systematically studied the role the moon has played on the development of life on Earth. But obviously, because of tides, it has been profound. By creating intertidal basins, the moon probably had something to do with coaxing life from the sea. Without the moon, Earth's spin axis would gyrate chaotically over tens of millions of years (as is actually the case on Mars), leading to wild climate fluctuations not conducive to the evolution of intelligent life. So in one sense, without the moon, there might not have been astronomers in the first place. — *William Sheehan, author of Changes of the Moon (which will be published next year by the University of Arizona Press)*

**Q: Is it the difference between the moon's and Earth's gravitational force that caused the moon to stop rotating (because it**

**has only one side facing the Earth)? Is it true that Earth will stop rotating in the future? — Vesna Nikolic, Etobicoke, Ontario, Canada**

A: A common misconception is that because the moon only shows one face to Earth, it doesn't rotate. As a matter of fact, the moon is rotating. Because its rotation period of 27.3 days is the same as its orbital period around Earth, earthlings only see one face. But if you were to fly in a spaceship above one of the moon's poles, you could see the moon rotate. In other words, the moon is rotating with respect to the stars, its so-called sidereal period. Earth will never stop rotating. — *Robert Naeye*

**Q: Heavy elements such as iron and gold originate in supernova explosions. So how many generations of stars would have had to form and explode in order to produce the elements existing today? — Jim Yancey, Fulton, Missouri**

A: With the exception of occasional outbursts in star formation, stellar birth and death happen continuously, so it is not really correct to speak of stellar "generations." We estimate that supernovae occur about once every 30 years or so in the Milky Way Galaxy. If the galaxy is 15 billion years old, it has seen about 500 million supernovae. The mass of the galaxy is about 200 billion suns. The heavy elements constitute about a hundredth of that, so the galaxy contains about 2 billion solar masses of the stuff. Each supernova has therefore contributed a few solar masses of heavy elements, give or take a very large fraction, which is consistent with theoretical estimates. Assuming complete mixing in the galaxy, each supernova has contributed about 10 million billion kilograms of mass to Earth. — *James Kaler, University of Illinois*

**Heavy elements such as iron and gold are born in violent supernova explosions. The equivalent of more than a billion solar masses may exist in the Vela supernova remnant.**

Royal Observatory, Edinburgh/Anglo-Australian Telescope Board







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### Deep Space Explorer™ Dobsonians

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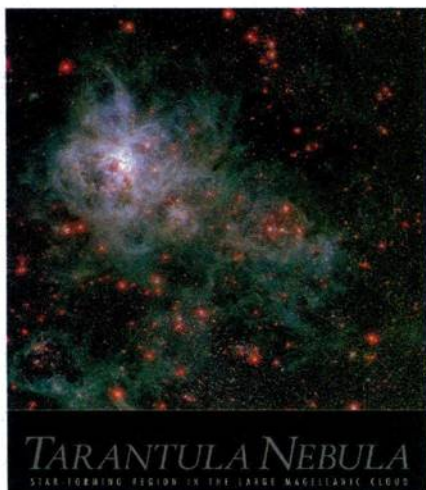
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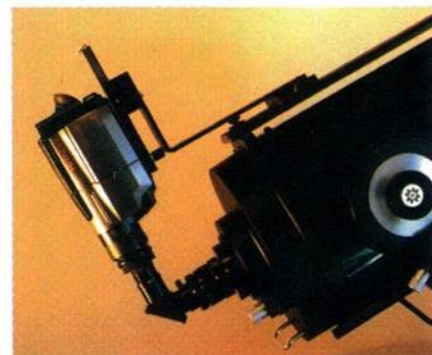
Hansen Planetarium Publications, 1845 South 300 West #A, Salt Lake City, UT 84115; phone, (800) 321-2369; fax, (801) 483-5484; website, <http://www.utah.edu/Planetarium/Publications.html>. Tarantula Nebula: regular, \$10; laminated stock, \$20.

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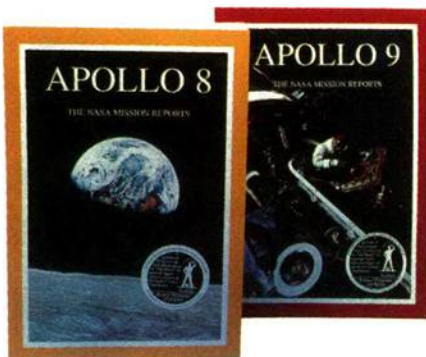


## A B O O K S

### Apollo 8: The NASA Mission Reports Apollo 9: The NASA Mission Reports

Robert Godwin, editor, 192 pages (Apollo 8), 240 pages (Apollo 9), Apogee Books, Burlington, Ontario, Canada, 1998; ISBN 1-896522-50-5 (Apollo 8) and 1-896522-51-3 (Apollo 9); paperback, \$13.95 (Apollo 8), \$14.95 (Apollo 9).

► These handsome books are the first two volumes in a series that will present the official reports of NASA manned missions. The books contain color photos and detailed information about each mission. A CD-ROM is also included. While the books aren't



the type one would sit down and read cover to cover, they will serve as invaluable reference tools for aficionados of human spaceflight. Subsequent volumes will cover later Apollo, Mercury, Gemini, and possibly Skylab and the space shuttle missions. The CD-ROMs included with the books that cover the Apollo moon landings will hold interactive movies. For more information, go to <http://www.cgpublishing.com/apogee.htm>.

### Our Worlds: The Magnetism and Thrill of Planetary Exploration

S. Alan Stern, editor, 172 pages, Cambridge University Press, New York, 1999; ISBN 0-521-63164-5, hardcover, \$54.95; ISBN 0-521-64440-2, paperback, \$19.95.

► Planetary scientist Alan Stern, a frequent contributor to *Astronomy*, edits these insider accounts of the golden age of planetary exploration. The chapters are written by eight

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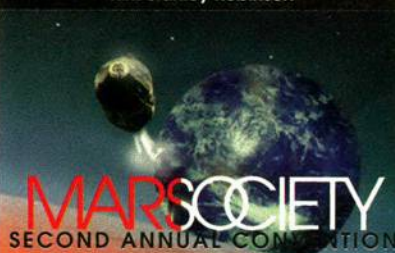
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**Cosmic Adventure: A Renegade Astronomer's Guide to Our World and Beyond**

Bob Berman, 255 pages, William Morrow and Co., New York, 1998; ISBN 0-688-14495-0, hardcover, \$25.

► The universe's self-proclaimed public relations rep is at it again. Bob Berman has constructed a roller-coaster ride through the profundities and hilarities of our universe out of 26 essays collectively titled *Cosmic Adventure: A Renegade Astronomer's Guide to our World and Beyond*. As in his 1995 book, *Secrets of the Night Sky*, Berman enlists a passion for astronomy, 25 years of science writing experience, and his own brand of spunky enthusiasm to reach out to curious readers and celestial devotees alike.

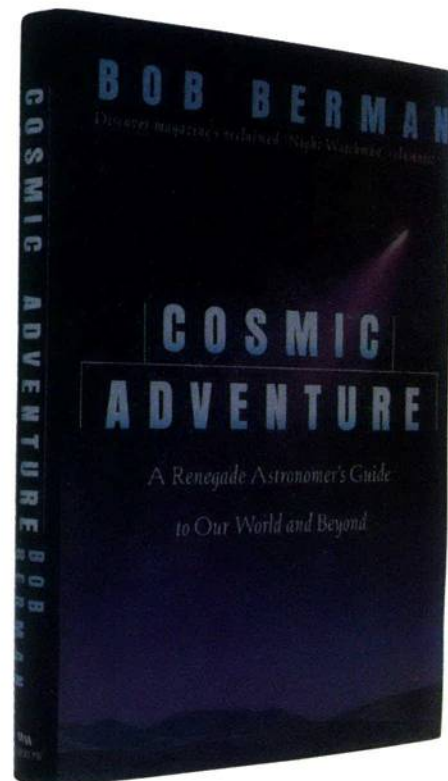
A brief introduction is Berman's way of saying, "Fasten your seat belts and hold on tight." Topics crop up in no particular order, but Berman appropriately begins with two of the book's most philosophical essays. He ponders: "Are events in our lives — or in the cosmos itself — random patterns shifting with blind abandon, or is there some greater design too intricate to be perceived by our limited vision?" He answers by noting

that humans developed naturally from Earth's environment, so whatever we do is what we were meant to do. Berman expertly transforms such abstract notions into visceral landmarks through his use of historical trivia, personal anecdotes, and down-to-Earth language.

With the structure of Berman's beliefs carrying you, your car tops the hill and potential energy turns kinetic. One provocative idea after another breezes by. Berman spends several pages pondering how an encounter with intelligent beings might play out. At other turns, he explains how to calculate the distance to the horizon out an airplane window, why efforts to unite science and faith are doomed to fail, and which amazing astronomers history has forgotten. Some readers may tire of jerking their heads left to right just to take everything in. Other readers, hair blown back and wild grins across their faces, will feel exhilarated by the author's quick-paced wit and thought-provoking "what-ifs."

In an essay called "Cosmic Blunders," Berman tackles the loop-to-loop of human fallibility. The 1990 fiasco of the Hubble Space Telescope's misshapen mirror may have cost \$1 billion, but when fixed, Hubble could resolve "cosmological issues that had vexed human brains since they first grew large enough to be tormented." After all, Berman says, we usually learn more from blunders than from doing things right, whether it's space exploration or life in general.

Factual blunders of his own doing sour a stretch of the ride. For instance, he cites the example of prime number



37, an oddball divisible by only itself and one. "Yet the numbers 111, 222, 333, 444, 555, 666, 777, 888, 999 are all divisible by 37 and nothing else," he writes. Wrong. A junior high math student, without the benefit of a calculator, would instantly know that all these numbers are divisible by one and three, and all the even numbers are divisible by two.

But even if you're derailed by an error or distracted by a disagreeable philosophical foray, it's easy to jump back aboard farther down the track. A glossary of more than 100 astronomical terms guides novices, and five dozen illustrations serve as signposts along the route. If you're looking for an intellectual joyride laced with the personal attitudes of a science writer known for his wit and intelligence, *Cosmic Adventure* is well worth its price. — Sarah Simpson



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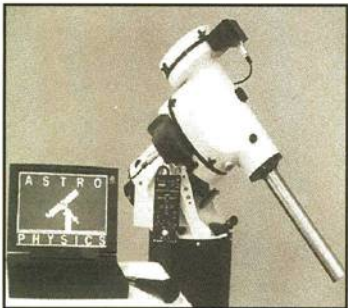
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### Sky Atlas 2000.0

Wil Tirion and Roger W. Sinnott, editors, 31 pages, Cambridge University Press, New York, 1998, ISBN 0-521-62762-1 (spiral deluxe edition), \$49.95.

► The long awaited second edition of *Sky Atlas 2000.0* is here. Newly revised with data from the Hipparcos satellite, the atlas plots 2,700 deep-sky objects and 81,312 stars down to magnitude 8.5 (nearly double the number of the first edition). It also includes marked constellation boundaries; symbols for variable, double, and multiple stars; and a plastic coordinate-grid overlay. The deluxe version features black stars with color-coded deep-sky objects and symbols. The *Sky Atlas 2000.0* is an essential part of any observer's library.

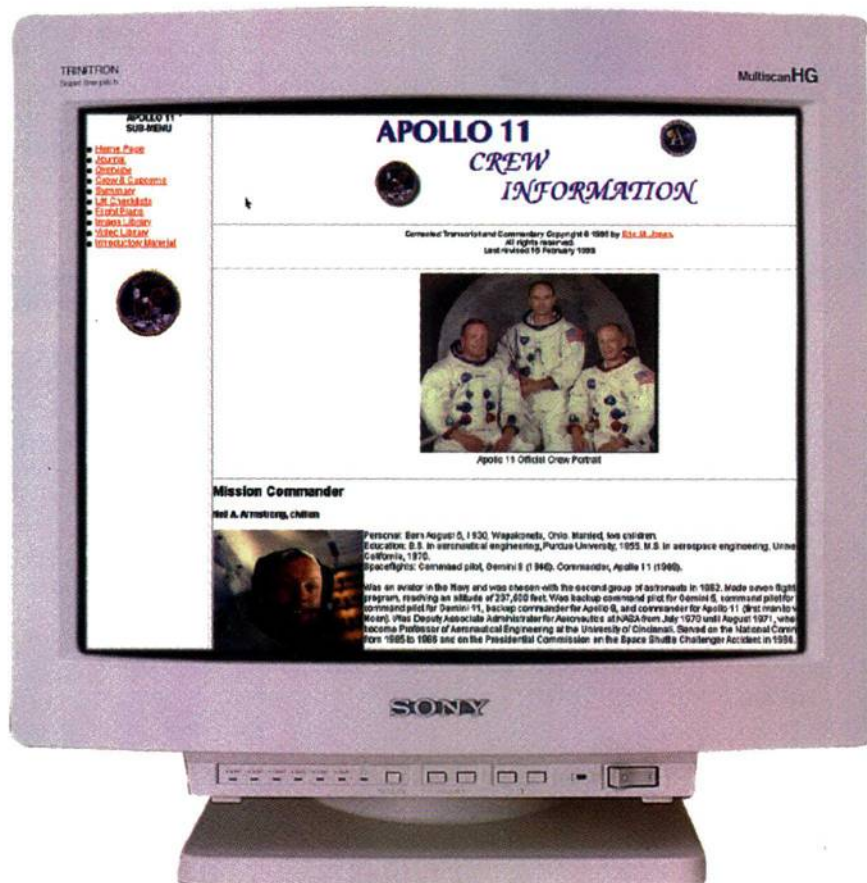
### Patrick Moore on Mars

Patrick Moore, 232 pages, Sterling Publishing, New York, 1998, ISBN 0-304-35069-9, hardcover, \$29.95.

► One of the world's leading astronomy authors presents a detailed account of the Red Planet and its pull on the imaginations of human beings through the centuries. Moore begins his chronicle with the planet's mythology. He then recounts early observations by such notable astronomers as Huygens, Flammarion, and others. The Mariner, Viking, and subsequent missions are also detailed. Numerous color photos, diagrams, and archival charts illustrate the Red Planet's geography, meteorology, and history. The discussion also includes an analysis of the possibility of martian life, and the feasibility of building a permanent manned base on the planet's surface. **A**

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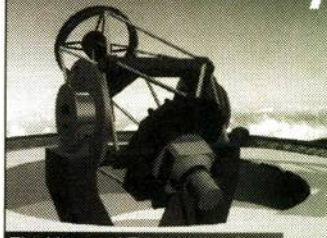
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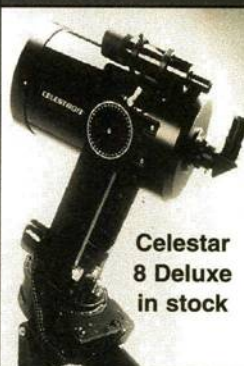


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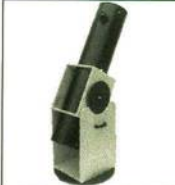
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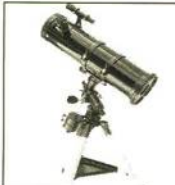
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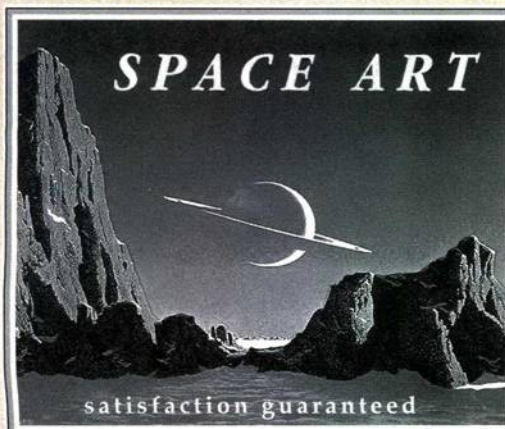
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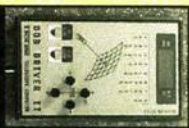
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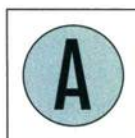


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For more information, contact the Spokane Astronomical Society, P. O. Box 8114, Spokane, WA 99204; e-mail, [astrocon-info@spokaneastronomical.org](mailto:astrocon-info@spokaneastronomical.org); website, <http://www.spokaneastro-nomical.org/astrocon99>.

#### **JULY 2–5 Universe '99**

► University of Toronto, Toronto, Ontario, Canada. Astronomy exhibition and lecture series co-sponsored by the Astronomical Society of the Pacific and *Astronomy* magazine. Contact the ASP, 390 Ashton Avenue, San Francisco, CA 94112; (415) 337-1100; website, <http://aspsky.org/u99/pa.html>.

#### **JULY 2, 16 Stargazer**

► Summit House Restaurant, The Big Mountain, Whitefish, Montana. Contact Syd Ryerson, The Big Mountain Ski and Summer Resort, P. O. Box 1400, Whitefish, MT 59937; (406) 862-2900; e-mail, [mktg@bigmtn.com](mailto:mktg@bigmtn.com); website, <http://www.bigmtn.com>.

#### **JULY 5–9, 11–15 Astronomy Institute for High School Students**

► Alfred University, Alfred, New York. Contact the Office of Summer Programs, Alfred University, Saxon Drive, Alfred, NY 14802; (607) 871-2612; e-mail, [summerpro@king.alfred.edu](mailto:summerpro@king.alfred.edu); website, <http://www.alfred.edu/summer>.



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#### **JULY 8–9 Rocky Mountain Star Stare**

► Pike National Forest, 50 miles west of Colorado Springs, Colorado. Pre-registration required. Contact Steve Bygren, c/o Colorado Springs Astronomical Society, P. O. Box 62022, Colorado Springs, CO 80962; CSAS event line, (719) 596-3672; website, <http://members.aol.com/bygrens/CSAS.html>.

#### **JULY 9–10 Star Party**

► Sola Fide Observatory, Austin, Minnesota. Contact Keith Snyder, 407 15th Street S.E., Austin, MN 55912; (507) 433-1903; e-mail, [kdsnyder@smig.net](mailto:kdsnyder@smig.net); website, <http://www.spamtownusa.com/imstar>.

#### **JULY 9–11 Gateway to the Universe**

► Munro Park, west of Powassan, Ontario, Canada. Sponsored by the North Bay and Sudbury Astronomy Clubs. Contact Tom Ouelette, (705) 474-7666 or Merlin Clayton, (705) 472-1182; e-mail, [Galaxy@efni.com](mailto:Galaxy@efni.com).

#### **JULY 9–11 Heart of New Mexico Star Party**

► Corazon Hill R.V. Park, 32 miles east of Las Vegas, New Mexico. For more information, phone (505) 641-5357; e-mail, [kb8exz@gatecom.com](mailto:kb8exz@gatecom.com).

#### **JULY 9–11 Mount Carleton Star Party**

► Armstrong Brook Campground, Mount Carleton Provincial Park, New Brunswick, Canada. Contact Adrien Bordage, (506) 635-3004; e-mail, [bordagea@nbnet.nb.ca](mailto:bordagea@nbnet.nb.ca); website, <http://www.osco.nb.ca/nbanb>.

#### **JULY 11–13 Annual Convention of the Society of Amateur Radio Astronomers**

► National Radio Astronomy Observatory, Greenbank, West Virginia. Contact Vince Caracci, (516) 798-8459; e-mail, [vinhell@juno.com](mailto:vinhell@juno.com).

#### **JULY 13–17 ASTROCON — Astronomical League Annual Convention**

► Eastern Washington University, Cheney, Washington. Contact the Spokane Astronomical Society, P. O. Box 8114, Spokane, WA 99204; website, <http://www.spokaneastronomical.org/astrocon99>.

#### **JULY 15–18 Starfest — Observing Convention**

► River Place Campground, Mount Forest, Ontario, Canada. Contact Andreas Gada, 26 Chryessa Avenue, Toronto, Ontario, Canada M6N 4T5; (416) 761-1798; website, <http://www.interlog.com/~nyaa>.



**JULY 16-18**

### Telescope-Making Contest

► Parc des îles de St-Timothée near Montréal, Quebec, Canada. Contact Yvan Pregent, (450) 377-2493; e-mail, ypregent@rocler.qc.ca; website, <http://www.rocler.qc.ca/caori/cafta.htm>.

**JULY 16-18**

### RocheSTARFest

► Lewis Wolk Observatory, Ionia, New York. Sponsored by the Astronomy Section of the Rochester Academy of Science. Contact Lori Englund, P. O. Box 20292, Rochester, NY 14602; e-mail, lenglund@frontiernet.net; website, <http://www.ggw.org/asras>.

**JULY 16-19**

### Island Star Party

► Vancouver Island, Canada. Sponsored by the Cowichan Valley StarFinders Astronomy Club. Contact Janet Curley, 2121 Tzouhalem Road #12, Duncan, BC, Canada V9L 5J5; (250) 748-2919 (eves.); e-mail, curley@islandnet.com; website, <http://starfinders.cvnet.net>.

**JULY 17**

### Astronomy Day

► Hofstra University in Hempstead, Long Island, New York. Noon to 5 P.M. Public star party at Robert Moses State Park, Field 2, will be held after dark. Contact Susan Rose, 655 Bellmore Avenue, East Meadow, NY 11554; (516) 489-2970; e-mail, sueken.rose@bigfoot.com; website, <http://members.aol.com/rjbenjamin/aos.html>.

**JULY 28**

### Hurricane Ridge Star Party

► Olympic National Park, Port Angeles, Washington. Contact John Gallagher at (360) 452-0260; e-mail, jgalla@pasd.wednet.edu; website, <http://www.tenforward.com/jffa>.

### CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to [tconley@astronomy.com](mailto:tconley@astronomy.com). Look for additional events at <http://www.astronomy.com>.

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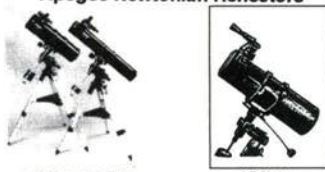
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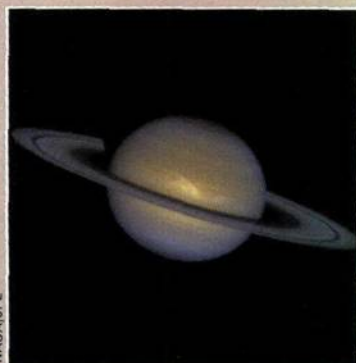
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# Astronomy



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CONJUNCTIONS

## Bagging the Closest Planet to the Sun

**Mercury presents itself as a bright bonus for conjunction viewers.**

► On March 5, 1999, the skies cleared at last over Montreal, Canada. So I went out hoping to see the so-called elusive Mercury. I knew that it was a difficult catch, having tried to spot it on less favorable occasions. Then I had seen a faint “star” with binoculars but couldn’t be positive it was the planet.

But this time....

The first remarkable object I saw was Venus and below it, Jupiter, which I had been following since last August. Higher than Venus I found Saturn, and then to the right of Jupiter — what was that? I knew there was no bright star in that region. So I decided that must be Mercury, but I found it much higher than I expected, and so easily! What surprised me most was that it appeared to be well out of the line formed by the other planets on the ecliptic, making almost a right angle with them.

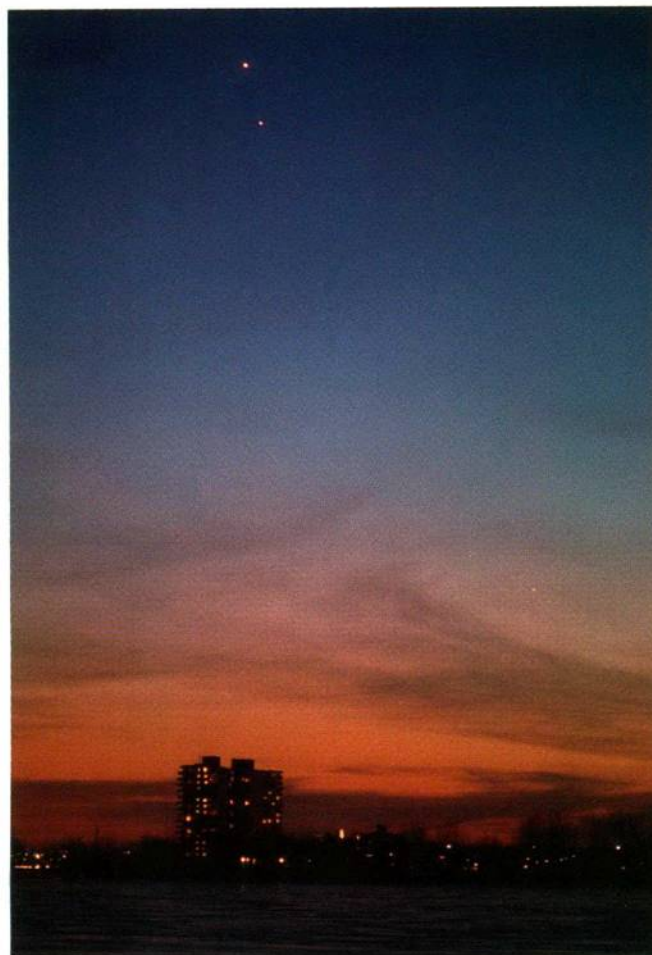
Back home, I checked with my planetarium software and found that I really had seen Mercury. Saturn, Jupiter, and Venus were all slightly south of the ecliptic, while Mercury was nearly six degrees north of the ecliptic. That’s why the first three appeared to line up and Mercury seemed signif-



**Venus/Jupiter Conjunction Hovers over an Oil Rig, Mercury in Sunset**

**DAN SCHECHTER**

(80mm lens at f/4, 120 format Kodak PPF 400 film, 20-second exposure taken on February 23, 1999)



**Venus, Jupiter, and Mercury**

**GEORGE LIV**

(100mm lens at f/2.5, Kodak Ektachrome film, 4-second exposure on February 24, 1999)





**Venus, Jupiter, and Moon over Oak Creek, Colorado**

**JAMES R. WESTLAKE, JR.**

(50mm lens at f/4, Kodak Elite 400 film, 20-second exposure  
taken 6:45 P.M. MST on February 19, 1999)





icantly out of line. Having these four planets in one view was quite a sight, probably the best of winter. Adding to this is that just before the planets appeared, I saw what I guess could be called a fireball (leaving a bluish-green trail) in the twilight-blue sky. The meteor lasted about two seconds; I could only wonder what the sight would have been like in a dark sky.

I returned on the 7th and 8th and Mercury was already fainter. After that, poor sky conditions hampered observing until the 15th, and by then I couldn't find it. Jupiter was much lower than the week before, grazing the horizon. Venus was getting closer to Saturn, and I noticed that since the Venus/Jupiter conjunction in February, the planets began moving really fast in the sky. I've also been able to observe this with Mars since mid-January. It's the first time I realized how fast they can move.

I often tell my wife that with great sights it pays off to look up even if you sometimes stumble on a rock or bump into someone looking down — or up! Just don't do it while crossing the street and you'll be all right. Naked-eye astronomy can be fun, too! **A**

*Serge Goyette is a music teacher and composer in Montreal.*

#### SHARE YOUR STORIES

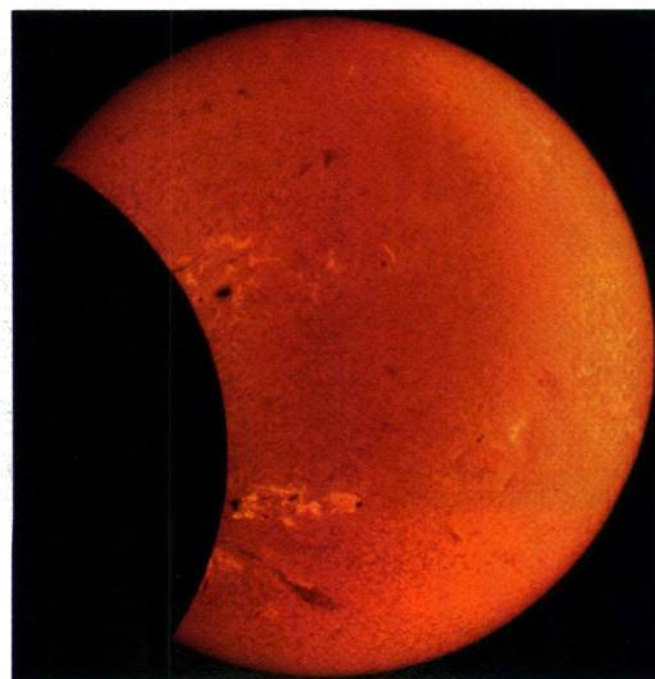
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#### NGC 7023 in Cepheus

GEORGE GREANEY & DEAN EASTON

(14-inch f/7 SCT, Fuji Super HG 400 film, composite of two 1-hour exposures)



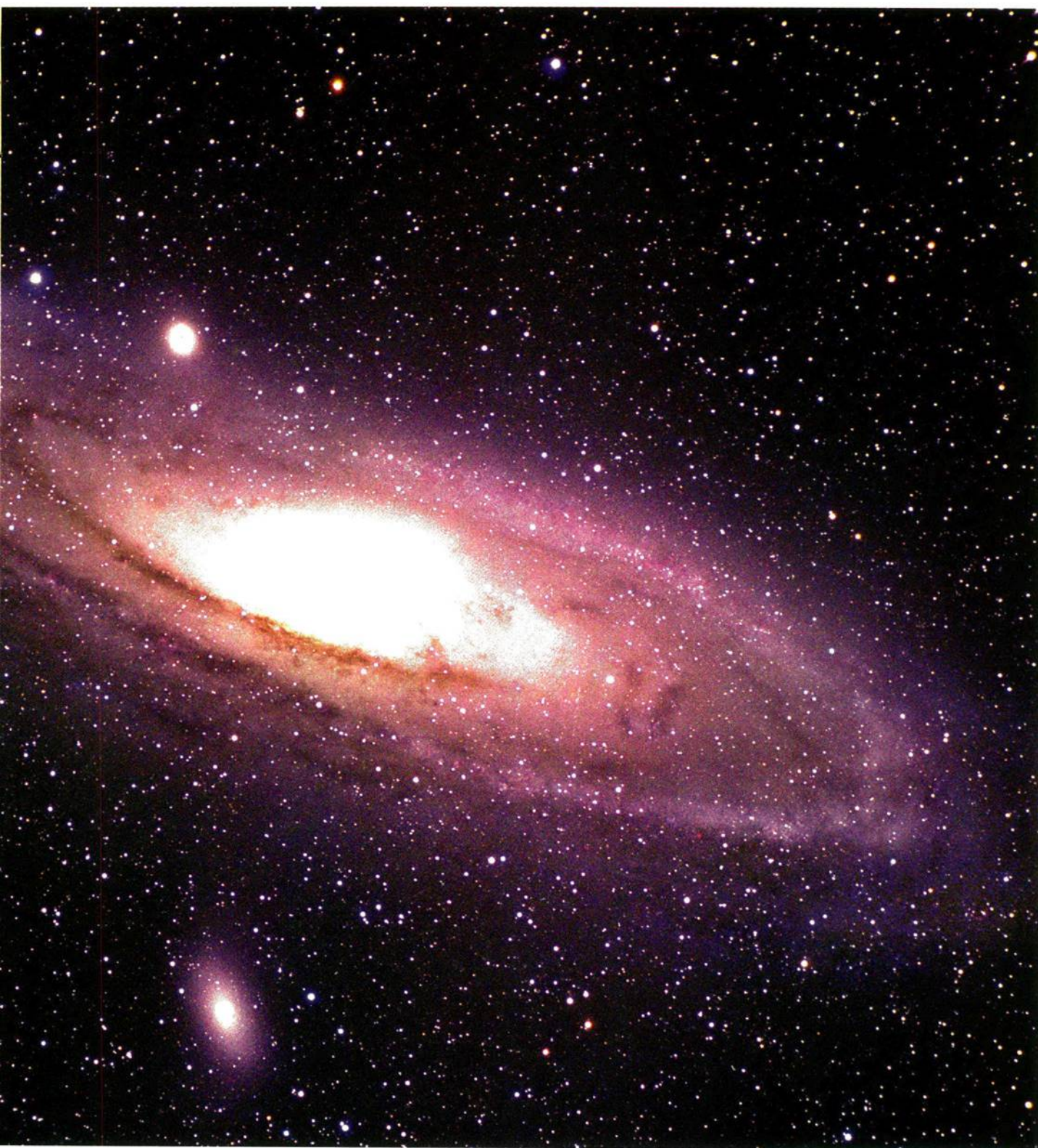
#### Sunspots at Eclipse's Edge

BARRY REYNOLDS

(2.5-inch refractor, Tech Pan film, Daystar H $\alpha$  filter,  $\frac{1}{25}$ -second exposure taken February 16, 1999)







**Andromeda Galaxy (M31)**

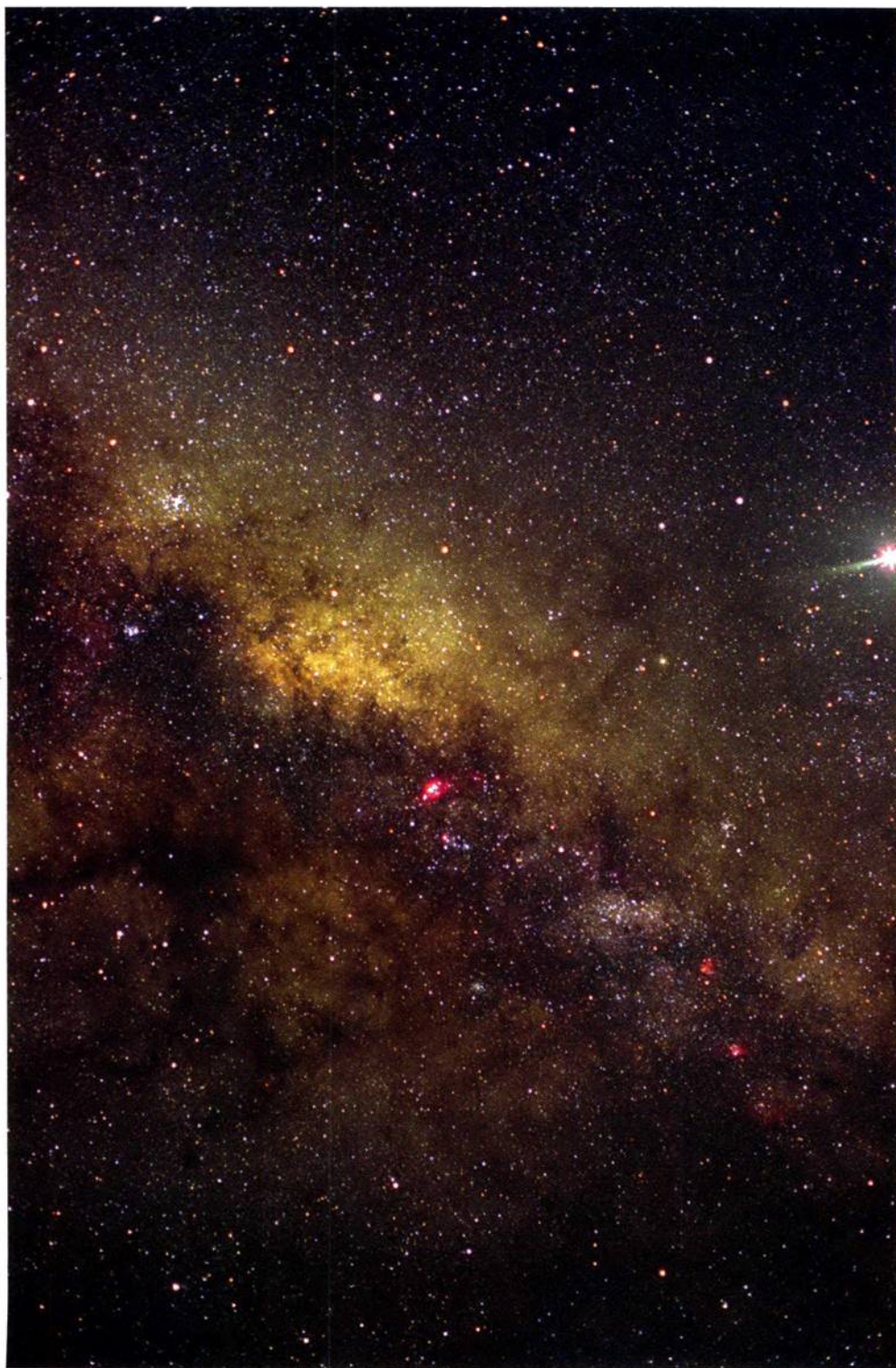
JASON WARE

(6-inch f/9 refractor, hypered Fuji HG 400 120 format film,  
45- and 90-minute exposures)





*This month's best astrophoto*



### **Milky Way Galaxy and Jupiter**

**SEAN EVERINGTON**

(5-inch Newtonian, 50mm lens at f/2.8, Kodak Gold III 400 ISO film, 5-minute exposure)

This image of our Milky Way Galaxy is centered on M20 and M8, with M6 and M7 at the upper left and Jupiter invading the right side.



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04:10 UT CM = 291



04:13 UT CM = 292



04:20 UT CM = 294



**The planet Mars, March 29, 1997.** Images by Dr. Donald Parker with a Meade 16" LX200 Schmidt-Cassegrain telescope and Meade Pictor 416XT CCD imaging camera. Dr. Parker employed eyepiece projection at f/49 with the following exposure times: blue 8.25 secs.; green 3.2 secs.; red 0.4 sec.; and infrared 0.8 sec. At the time of these exposures Mars' angular diameter was 14 arcsecs.

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